CHAPTER

6

Industrial Conservation Program

6.1 INTRODUCTION

The purpose of the Industrial Conservation Program is to move industrial users within the Phoenix Active Management Area (AMA) to the greatest level of water use efficiency economically attainable given the use of the latest available water conservation technology. By definition within the Groundwater Code (Code), industrial users are groundwater users, although they may also receive renewable supplies in addition to their groundwater use. Efficient use of groundwater and the replacement of groundwater sources with renewable supplies during the third management period will ensure that industrial users make effective strides toward contributing to the AMA's statutorily mandated goal of safe-yield of groundwater by the year 2025.

"Industrial use" is defined in the Code as "a non-irrigation use of water not supplied by a city, town, or private water company, including animal industry use and expanded animal industry use." A.R.S. § 45-561.5. Industrial users either pump groundwater from their own wells or receive it from irrigation districts pursuant to Type 1 or Type 2 non-irrigation grandfathered rights or groundwater withdrawal permits. These rights or permits have annual volumetric groundwater allotments. The Glossary of Terms at the end of this management plan contains a description of water rights and permits. Non-residential uses, such as commercial, industrial, and institutional facilities supplied by a municipal water provider, are not industrial users as defined under the Code and are administered under Chapter 5, the Municipal Conservation Program. The primary water uses by industrial users are processing, cooling, and landscape watering. While some water uses are common to most industrial facilities, industrial uses are quite diverse, each with its own unique characteristics and conservation potential. For the third management period, there are general conservation requirements that apply to water use characteristics common to all industrial users (section 6.2).

In addition to these general requirements, specific conservation requirements apply to the following industrial uses:

- Turf-Related Facilities;
- Sand and Gravel Facilities;
- Large-Scale Power Plants;
- Large-Scale Cooling Facilities;
- Dairy Operations;
- Cattle Feedlot Operations;
- New Large Landscape Users; and
- New Large Industrial Users

These specific conservation requirements are separately addressed in subsequent sections of this chapter (sections 6.3 through 6.10). In general, each of the subsections contain all or some of the following: (1) an introduction, (2) water use by the subsector, (3) First and Second Management Plan program development, (4) issues and Third Management Plan development, (5) program description, (6) non-regulatory efforts, (7) future directions, and (8) subsector conservation requirements.

Industrial users with groundwater rights or permits used about 4 percent of the AMA's water use in 1995, or about 83,000 acre-feet. Although this is a small proportion of total water use in the AMA, 86 percent of this use is groundwater. Users of non-groundwater sources are relatively uncommon; most users use exclusively groundwater. While it is projected that most new non-residential water uses will be served by municipal water providers and will not become industrial users in the AMA, industrial water use is expected to show some increase through the year 2025. This increase will be the result of growth in the number of facilities such as golf courses and homeowner association common areas that accompany new residential development. While new residential development is required to use renewable water sources under the Assured Water Supply Rules (AWS Rules), certain non-residential uses associated with these developments have chosen to secure groundwater rights.

Industrial user contribution to safe-yield was expected to be achieved by water use efficiency gained by the conservation requirements described in this chapter, limitations on the creation of new industrial users, and the possibility of the Arizona Department of Water Resources (Department) purchasing and retiring non-irrigation grandfathered rights. Expectations envisioned in the First and Second Management Plans of water conservation and renewable supply use by industrial users have not been completely met by industrial users. For the third management period, the Code requires that industrial conservation programs are designed with consideration of the latest commercially available conservation technology, consistent with reasonable economic return. Although progress has been made by some industrial users to implement more water efficient design, such as target-style golf courses, the economics of implementing water conservation technology has been questioned. Besides addressing water use efficiency, the First and Second Management Plan Industrial Conservation Programs incorporated incentives to encourage renewable supply use by industrial users. These incentives have proven largely ineffective. The relatively low cost of groundwater compared to renewable supplies has strongly deterred existing industrial users from stopping or reducing groundwater use and replacing that use with renewable supplies.

The difficulty of moving industrial users to renewable supplies refocuses attention toward existing and new groundwater withdrawal authority by industrial users. Type 1 and Type 2 non-irrigation grandfathered rights were created in the Code to identify and quantify the amount of groundwater pumped by industrial users at the time of enactment, thus allowing existing industrial users to be "grandfathered in." This grandfathering action would allow them to continue to conduct their business and pump groundwater without undue hardship. Since the creation of the Code, new industrial users were given rights or permits to withdraw groundwater (usually the creation of Type 1 non-irrigation grandfathered rights or the issuance of General Industrial Use groundwater withdrawal permits) only if the new user was not supplied water by a city, town, or private water company, or did not have access to renewable water supplies such as unused or "excess" Central Arizona Project (CAP) water, surface water, or effluent. Although this approach is based on the reasoning that a new industrial use that is supplied water by a city, town, or private water company is likely to be supplied in whole or in part with renewable supplies, the authority to grant new groundwater withdrawal authorities that would increase total groundwater withdrawals remains, contradicting efforts to reduce groundwater overdraft.

Current authorities do not allow the Department to require conversions to renewable resources or to require a replenishment obligation for groundwater used. As a result, the contribution to overdraft by industrial users is disproportionately large and, if current trends continue, is likely to grow. Increased conservation efforts, increased use of renewable supplies, and possible statutory changes regarding the conditions of issuance of new groundwater withdrawal authority are needed for industrial users to effectively contribute toward achieving the safe-yield goal in the AMA by 2025.

6.1.1 Statutory Provisions

The Code requires that all management plans contain a conservation program for industrial users. For the third management period, the director of the Department is required to establish in each plan:

> additional conservation requirements for all non-irrigation uses of groundwater to be achieved by the end of the third management period and may establish intermediate conservation requirements to be achieved at specified intervals during the third management period. . . . For industrial uses including industrial uses within the exterior boundaries of the service area of a city, town, private water company or irrigation district, the program shall require the use of or establish conservation requirements based on the

use of the latest commercially available conservation technology consistent with reasonable economic return. A.R.S. § 45-566(A)(2).

The Code also requires the establishment of conservation requirements for certain municipally served uses called "individual users." A.R.S. § 45-566(A)(2). (See Chapter 5.) Because their water use characteristics and conservation potential were identical to industrial users, municipally served turf-related facilities were regulated as individual users and given conservation requirements identical to turf-related facilities that were industrial groundwater right and permit holders in the First Management Plan; in the Second Management Plan, municipally served large-scale cooling facilities were also regulated as individual users. Thus, regardless of the source of water, whether from municipal water providers or pursuant to a non-irrigation grandfathered groundwater right or permit, all turf-related facilities and large-scale cooling facilities were subject to identical conservation requirements in the Second Management Plan. In 1988, a change to the Code allowed the Department to directly regulate individual users by making the facility, rather than the municipal water provider serving them, responsible for compliance with the conservation requirements in the management plan.

6.1.2 Industrial Program Development

The Industrial Conservation Program has evolved into a more technically sophisticated program since the First Management Plan. This has been the result of considerable input and cooperation by the regulated community, as well as investigative efforts by the Department.

The First Management Plan requirements stressed water use efficiency and other general requirements. The Management Plan included specific conservation programs only for turf-related facilities, electric power plants, sand and gravel facilities, and other industrial users. Conservation requirements for these water use categories continued into the second management period. As a result of consultant studies done for the Second Management Plan, additional conservation requirements were added in the Second Management Plan for new large cooling users, dairy operations, cattle feedlots, new large industrial users, and new large landscape users. In addition, more specific effluent incentive provisions were included for turf-related facilities.

Development of the third management period conservation requirements included extensive participation by a wide cross-section of industry representatives, including facility managers, consultants, municipal representatives, vendors, land developers, architects, and academic research specialists. The following Technical Advisory Committees (TACs) were formed for the development of specific conservation requirements found in the Industrial Conservation Program for the third management period:

- Turf-related facilities (Phoenix AMA only, a separate committee advised the Tucson AMA);
- Dairy operations/feedlots (a joint committee for the Phoenix, Pinal, and Tucson AMAs);
- Cooling towers/electrical power plants (a joint committee for the Phoenix and Tucson AMAs); and
- Sand and gravel facilities (a joint committee for the Phoenix, Pinal, and Tucson AMAs)

Collectively, over 30 meetings were held with the committees over an 18-month period. Committee members had an opportunity to help formulate and put forth conservation requirement alternatives, provide industry perspective and expertise on alternatives and concepts, and review final program alternatives.

Categories of conservation requirements for the third management period are the following:

- general industrial conservation requirements, which apply to all industrial users;
- turf-related facilities (facilities of 10 or more acres of water-intensive landscaping) have an annual allotment based upon the number of acres of turf, bodies of water, and low water use landscaping;
- sand and gravel facilities, which have operating standards and must develop a conservation plan;

- large-scale power plants, which have water efficiency standards for their cooling towers;
- large-scale cooling facilities, which have water efficiency standards;
- dairy operations, which have an annual allotment based on herd size, or may apply for a best management practices program;
- cattle feedlot operations, which have an annual allotment based on herd size;
- new large landscape users, which have landscape efficiency design standards; and
- new large industrial users, which have water use efficiency and conservation plan requirements.

In most instances, specific conservation requirements for the third management period are not significantly different from those in the Second Management Plan. All specific conservation requirement programs have retained essentially the same structure and character. Conservation requirements in the First and Second Management Plans have been effective in improving water use efficiency for certain industrial subsectors. Turf-related facilities, especially golf courses, have been designed with considerably less water-intensive landscaping than in the past. In the Third Management Plan, a number of technical corrections have been made, requirements have been added, additional program alternatives have been included, and renewable supply use incentives have been added or adjusted to be more effective.

Some AMA management plans have a conservation program for metal mining facilities that use more than 500 acre-feet per year. If an industrial user meeting this definition should be constructed in the Phoenix AMA during the third management period, this plan could be modified to include the metal mining facilities conservation program.

6.1.3 Industrial Program Issues

The most significant issues facing the Industrial Conservation Program include the following:

- The need for greater use of renewable supplies by industrial users
- The need to match industrial uses with water quality that may be less than ideal or unsuitable for potable uses in order to make the most efficient use of water in the AMA for both potable and non-potable uses
- The concern raised by the large volume of unused groundwater allotments
- The concern raised by the ability of industrial users to obtain new groundwater withdrawal authority in even the most critical areas of the AMA
- The sector's disproportionately large contribution to overdraft.

6.1.3.1 Use of Renewable Supplies by Industrial Users

First and Second Management Plan incentives encouraging renewable supply use by industrial users have proven less effective than anticipated. Incentives for effluent use were offered to turf-related facilities in the Second Management Plan. If a facility used 100 percent non-groundwater supplies, it was exempt from the Department's conservation requirements. As a rule, most third management plan programs include new or more substantial incentives for the use of effluent or the recycling or reuse of industrial wastewater.

Currently, the only industrial subsector that uses renewable supplies is turf-related facilities that receive effluent, surface water, or CAP water from municipal providers or irrigation districts or, to a lesser degree, private sources. Many factors impede the ability of the industrial sector to directly and indirectly use renewable water supplies and contribute to reaching the safe-yield goal of the AMA. Lack of proximity or right to renewable supplies, reliability, cost, supply ownership, and water quality issues are constraints to the use of effluent and CAP water. While turf-related facilities have had no significant water quality problems using effluent, other industrial users could require pretreatment of effluent to remove salts and other constituents. For example, industry representatives have indicated that concrete does not meet industry standards if effluent is used in place of groundwater. Although the AMA has either added or bolstered existing renewable supply incentives for the third management period, limited statutory authority exists for overcoming obstacles to the use of renewable supplies by industrial users.

Surface water, primarily from the Salt, Verde, and Agua Fria Rivers, is the only renewable supply that is consistently competitive in cost with groundwater and fairly accessible to industrial users. Use of this supply, however, is limited to industrial users whose lands have appropriated surface water rights within an irrigation district's boundaries. It may also be available, in rare cases, if they directly divert surface water from a river or stream pursuant to a surface water right. This source is not a viable option for new industrial uses outside of irrigation district boundaries.

CAP water is legally available to industrial users either through an original allocation subcontract with the Central Arizona Water Conservation District (CAWCD), the managing entity of CAP, or through a contract for "excess" CAP water (CAP water that has not been put to use by those with original subcontracts). Long-term, continuously available CAP water for use by industrial users, however, is limited. Only one industrial user currently has a CAP allocation and year-to-year contracts for excess CAP water are not a reliable long-term source; once other subcontractors use their CAP supply, there will be no excess CAP water available to industrial users. Industrial users may arrange an agreement to have allocated or excess CAP water conveyed through a municipal provider's distribution system or through an irrigation district's canals and laterals.

Effluent generally must be conveyed to users in dedicated systems. Effluent is available either from small package plants built by a developer of a master planned community, which are designed to treat influent from the community and distribute it to a non-residential use within that community (such as a golf course), or from larger regional wastewater treatment plants. Much of the influent from mature, older areas of Phoenix, Glendale, Scottsdale, Tempe, and Mesa goes to the 91st Avenue Wastewater Treatment Plant, which is downstream from most industrial users in the Phoenix metropolitan area. Piping effluent to industrial users in older areas would require the development of an extensive effluent distribution system from the plant to users. Currently, neither municipal water providers nor industrial users have much incentive to assume the financial burden of developing such a system. Municipal water providers are increasingly developing distribution systems to carry effluent to non-residential users from wastewater treatment plants in areas of new growth. It is easier and cheaper to develop such systems in new growth areas than in older areas. This is especially true in North Scottsdale, Phoenix north of the CAP canal, Chandler, and Gilbert. While this will likely forestall new industrial groundwater uses in those areas of the AMA, the cost of developing such systems is usually greater than the cost of groundwater. Of all renewable supplies, effluent is the one source that will grow and be most readily available to industrial users. Most effluent is delivered to individual users served by municipal water providers and is not used by industrial users. Individual users used over 4,000 acre-feet of effluent in 1995 while industrial right holders used over 3,000 acre-feet of effluent in 1995.

Only a decade ago, industrial users who wanted to use renewable supplies had no other choice other than to use them directly. Today, industrial users who cannot directly use surface water, CAP water, or effluent may do so indirectly. One method would have the industrial user obtain a water storage permit, lease space at an underground storage facility, and recharge the renewable supply back into the aquifer. (See Chapter 8.) Credits for such storage are accrued by the industrial user and may be expended or "recovered" by pumping groundwater from the industrial user's wells. Usually when water is recovered, it is legally considered the same as the source that was stored; if effluent is stored at an underground storage facility, then the credits recovered are legally considered effluent. Although this option alleviates the need to build costly distribution systems to industrial users, indirect use of renewable supplies has expenses that usually make the option more costly than pumping groundwater. Industrial users who want to store renewable supplies must obtain the necessary permits, purchase the water for storage, pay for leasing space at a facility, and pay for pumping (recovery) costs. Perhaps a more likely option for the industrial user is to purchase credits from a party that has stored water and is willing to sell their credits. The industrial user can then use the purchased credits to recover a renewable supply that has been stored.

6.1.3.2 Matching Water Quality and Uses

Each industrial user category has its own water chemistry requirements related to the particular product or process involved. Some users may require high quality groundwater while others do not. For example, turf-related facilities are able to use effluent without any significant adverse impact, and sand and gravel facilities can use effluent for aggregate washing. Poor quality groundwater may be acceptable for certain industrial uses. Use of industrial wastewater may also be a potential water supply and should be investigated. Obvious constraints on its use include location of the supply in relation to the facility, cost, and pre-treatment needs.

In 1997, the Legislature enacted legislation significantly revising the Water Quality Assurance Revolving Fund (WQARF) program to provide incentives for the use of remediated groundwater to facilitate the treatment of contaminated groundwater. Among other things, the WQARF legislation provides that when determining compliance with management plan conservation requirements, the Department shall account for groundwater withdrawn pursuant to approved remedial action projects under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Title 49, Arizona Revised Statutes, consistent with the accounting for surface water. Laws 1997, Ch. 287, § 51(B). See Chapter 7, section 7.4.4.6.3. Groundwater withdrawn pursuant to an approved remedial action project retains its legal character as groundwater for all other purposes under Title 45, Arizona Revised Statutes, including all other laws regulating groundwater withdrawal and use such as the assessment of withdrawal fees pursuant to A.R.S. § 45-611, *et seq.*, as well as laws regulating water exchanges as set forth in A.R.S. § 45-1001, *et seq.*, the transportation of groundwater as set forth in A.R.S. § 45-541, *et seq.*, withdrawals of groundwater for transportation to active management areas as set forth in A.R.S. § 45-551, *et seq.*, and underground water storage, savings, and replenishment as set forth in Title 45, Chapter 3.1, Arizona Revised Statutes.

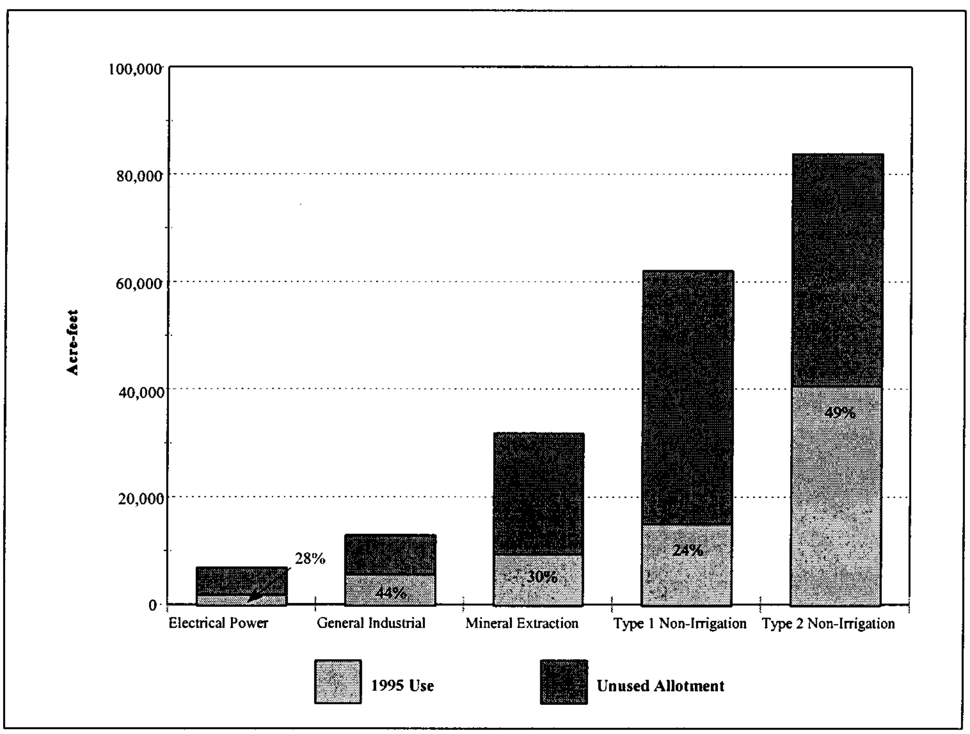
For each approved remedial action project, the annual amount of groundwater that is eligible for the remediated groundwater accounting incentive is the maximum annual volume of groundwater that may be withdrawn pursuant to the project, as specified in the consent decree or other document approved by the Environmental Protection Agency (EPA) or Arizona Department of Environmental Quality (ADEQ). However, if the project was approved prior to June 15, 1999 and the maximum annual volume of groundwater that may be withdrawn pursuant to the project is not specified in a consent decree or other document approved by the EPA or ADEQ, the annual amount of groundwater that is eligible for the remediated groundwater accounting incentive is the highest annual use of groundwater withdrawn pursuant to the project prior to January 1, 1999. The director may modify the annual amount of groundwater that is eligible for the accounting incentive if an increase in withdrawals is necessary to further the purpose of the project or if a change is made to the consent decree or other document approved by the EPA or ADEQ.

In order to qualify for the remediated groundwater accounting incentive, a person must notify the director in writing of the anticipated withdrawal of the groundwater prior to its withdrawal. The notification must include a copy of a document approved by ADEQ or the EPA such as the Remedial Action Plan (RAP), Record of Decision (ROD) or consent decree. Unless specified in the document, the notification must include the volume of groundwater that will be pumped annually pursuant to the project, the time period to which the document applies, and the annual authorized volume of groundwater that may be withdrawn pursuant to the project. The notification must also include the purpose for which the remediated groundwater will be used and the name and telephone number of a contact person. Additionally, at the time the notice is given, the person must be using remediated groundwater pursuant to the approved remedial action or must have agreed to do so through a consent decree or other document approved by ADEQ or the EPA. Remediated groundwater which qualifies for the accounting must be metered and reported separately from groundwater that does not qualify for the accounting. (See section 6-204 of the Conservation Requirements for All Industrial Users.)

6.1.3.3 Unused Allotment

A large volume of unused groundwater right and permit allocations are associated with the industrial sector. Groundwater rights and permits held by industrial users in 1995 totaled over 212,000 acre-feet. Use pursuant to these rights and permits was only 34 percent of the total allotment in 1995. Figure 6-1 shows total use and total allotment for Power, Mineral Extraction, Type 1 non-irrigation grandfathered rights, and Type 2 non-irrigation grandfathered rights in the AMA in 1995. Type 2 non-irrigation grandfathered rights are not appurtenant to the land and may be used anywhere in the AMA for any non-irrigation purposes. They may be bought, sold, or leased in whole and in part. Type 2 rights have the greatest flexibility for potential use in the future, possibly in areas or subbasins where groundwater decline is already or will be severe. With over 43,000 acre-feet of Type 2 non-irrigation grandfathered rights not used in 1995, these rights may prove to be a major obstacle to reducing groundwater dependence in the industrial sector. While some of the unused allotments may never actually be put to use, it is not possible to predict future utilization. If these 43,000 acre-feet were pumped, it would be a serious hindrance to reaching safe-yield unless it were offset through replenishment with imported renewable supplies. Type 1 rights and some Type 2 rights may be extinguished for assured water supply credits (mineral extraction and electric power Type 2 rights may not be extinguished for this purpose) by municipal water providers. In addition, beginning in 2006, the Department may collect fees from groundwater users to purchase and retire grandfathered groundwater rights. Both mechanisms are opportunities that are currently available to permanently extinguish existing industrial rights.

FIGURE 6-1
1995 WATER USE AND ALLOTMENTS
PHOENIX ACTIVE MANAGEMENT AREA



6.1.3.4 Groundwater Withdrawal Permits

General Industrial Use (GIU) Permits are issued under A.R.S. § 45-515 for industrial uses located outside of service area boundaries pursuant to certain conditions. Permits may also be issued for mineral extraction and metallurgical processing under A.R.S. § 45-514. These permits allow groundwater pumping in addition to withdrawals pursuant to existing industrial rights. The total permitted GIU volume in the Phoenix AMA in 1995 was nearly 12,900 acre-feet, although the amount used was approximately 5,700 acre-feet. Historically, permits have been readily issued and the number of permit applications may increase in the future as the availability of Type 2 rights to serve industrial uses becomes more limited.

6.1.3.5 Sector Equity to Reduce Overdraft

While some industrial users use surface water, effluent, CAP water, or industrial wastewater, the vast majority of industrial water use is of groundwater. Although industrial use is a relatively small water use sector (4 percent of AMA water use) compared to municipal and agricultural uses, industrial use accounts for a disproportionately large amount of groundwater overdraft, despite incentives included in the First and Second Management Plans to encourage the use of renewable water supplies. Because industrial users have the legal authority to withdraw groundwater up to the annual allotment of their rights or permits, and since the cost of pumping groundwater is relatively low compared to the cost of most other sources of water, there is little economic incentive for industrial users to switch to renewable water supplies. If financial incentives remain inadequate, groundwater use by industrial users may increase in the future.

In the Phoenix AMA, significant amounts of industrial groundwater right allotments are unused, representing a potential increase in groundwater pumping allowable under statute. The industrial user also has relative ease of obtaining further groundwater withdrawal authority, either by converting an irrigation grandfathered right to a Type 1 non-irrigation grandfathered right or by obtaining an industrial use permit. The access to large quantities of unused groundwater allotments and the ability for the sector to increase withdrawal authority illustrates how capable the sector is at further contributing to the problem of overdraft.

Users in other sectors have limits imposed on their abilities to mine groundwater. The agricultural sector is limited to irrigating land that was legally irrigated from 1975 to 1979. Under AWS Rules, new municipal growth is restricted in the amount of groundwater that may be used to serve such development; renewable resources must be used. When a municipal provider pumps water in excess of the AWS Rules, it must pay a replenishment tax to the Central Arizona Groundwater Replenishment District (CAGRD), which uses the revenue generated by the tax to replenish the aquifer.

The industrial sector has none of these restrictions. It can continue to pump or establish pumping in areas or subbasins where municipal providers have undertaken great expense to stop groundwater pumping to improve physical availability of groundwater in the area. Although industrial users account for 4 percent of total water use in the AMA, they use 7 percent of the groundwater and account for 13 percent of groundwater overdraft.

6.1.4 <u>Future Directions</u>

Maintaining water use efficiency, providing conservation and technical assistance, and developing opportunities for renewable resource use are the most likely future directions for industrial users. The future of industrial users in relation to the AMA's goal of safe-yield by 2025 is largely shaped by the potential for growth in groundwater use and constraints from replacing groundwater use with renewable supplies.

For the industrial sector to contribute more to the achievement of the AMA management goal of safe-yield, viable renewable resource use mechanisms must be put in place. Although most effluent is municipally controlled and is projected to be used by municipally served turf-related facilities, potential may exist for CAP and effluent use by industrial users in the future. For this to occur, there must be either regional infrastructure cost sharing opportunities for direct use that make it economically viable to use a renewable supply, or low cost replenishment mechanisms whereby pumped groundwater would be replenished by a renewable supply elsewhere in the AMA under certain conditions.

Groundwater pumping by industrial users in critical areas of the AMA is of particular concern. Critical areas may include areas of severe overdraft, rapidly declining water levels, land subsidence and earth fissuring, or areas vulnerable to degraded water quality. The Department may develop water management strategies to address localized water conditions, promoting withdrawals in areas experiencing groundwater recharge and restricting withdrawals from areas experiencing severe declines. For industrial uses, this could mean limiting Type 1 non-irrigation grandfathered right conversions, buying out or providing incentives for extinguishing existing grandfathered rights in specified areas, or limiting new General Industrial Use permits and industrial users in critical areas.

Once created, Type 1 non-irrigation rights have the authority to pump groundwater in perpetuity in such areas. In addition, little can be done to prevent a Type 2 non-irrigation right to move into a critical area from other parts of the AMA. Only limited ability exists to prevent the issuance of groundwater withdrawal permits in a critical area.

Apart from the groundwater right retirement provision in the Code and the groundwater right extinguishment provisions in the AWS Rules, no statutory authority exists to reduce industrial groundwater rights. The Department has decided not to include a grandfathered right purchase and retirement program in the Third Management Plan at this time. The extent to which the extinguishment provisions will limit industrial use is impossible to predict. In the future, it may be necessary to explore groundwater replenishment approaches to offset a portion of the industrial use of groundwater. Expanding the authority of the CAGRD to recharge excess CAP water outside of the Assured Water Supply Program or establishing a separate replenishment authority for industrial users are possible approaches. Statutory change would be necessary to implement either mechanism.

It may be reasonable to consider either conditioning the issuance of a GIU permit on the permit holder's agreement to replenish the aquifer with a renewable supply or changing the statutory language to place more conditions on obtaining a GIU permit. Alternatively, a legislative change to allow the director to deny an application for a GIU permit if the permit would have an adverse effect in areas of the AMA deemed to have critical conditions may need to be considered.

Industrial water uses may change as new technologies are developed during the third management period. Research may need to be conducted during the third management period to investigate water-conserving opportunities arising from the use of these technologies by industrial users. This research could be used to develop conservation requirements for the Fourth Management Plan.

6.2 ALL INDUSTRIAL USERS

6.2.1 Introduction

The conservation requirements in this section apply to all industrial water users. In addition to these requirements, certain industrial users are also required to comply with conservation requirements specific to their type of water use under other sections of this chapter. For example, a sand and gravel facility is required to comply with the requirement in this section to use low-flow plumbing devices at the facility to the maximum extent possible, and must also comply with the conservation requirements in section 6.4.6 of this chapter.

The following industrial users are required to comply with the conservation requirements for all industrial users in this section, as well as conservation requirements for their specific type of water use in other sections of this chapter: turf-related facilities, sand and gravel facilities, large-scale power plants, large-scale cooling facilities, dairy operations, cattle feedlot operations, new large landscape users, and new large industrial users. All remaining industrial users are referred to in this section as "other industrial users" and are required to comply only with the conservation requirements for all industrial users in this section.

6.2.2 Water Use by Other Industrial Users

Other industrial users in the Phoenix AMA used approximately 12,500 acre-feet of water in 1995, which accounts for approximately 15 percent of the total groundwater withdrawals by industrial users in the Phoenix AMA. Many different types of commercial and manufacturing uses are included in this category. The largest volume of water is used in the aerospace, food processing, electronics, hospital, and non-durable goods manufacturing industries. Water uses commonly include cooling; landscaping; and sanitary, kitchen, and industrial processing.

In the Phoenix AMA, 304 water rights and permits are associated with this category. The total annual groundwater allotment of rights and permits associated with this category, excluding dewatering and poor quality water permits, is nearly 71,000 acre-feet. Other than 12,000 acre-feet of Type 1 non-irrigation grandfathered rights associated with the Estrella development in Goodyear, no owner holds a very large allotment.

While some users are expected to grow in the future, total demand for other industrial users is expected to remain approximately the same as current water use levels through the year 2025. It is anticipated that most future industrial development will be served by municipal providers because commercial and industrial development generally occurs within their service areas.

6.2.3 Program Development and Issues

In the First Management Plan, other industrial users were required to avoid waste and to make efforts to recycle water. In addition, they were prohibited from using single-pass cooling or heating in their facilities. These requirements and others were included in the Second Management Plan for all industrial users.

Consultant studies conducted in preparation of the Second Management Plan investigated water use associated with landscaping, heating and cooling, and sanitary and kitchen water use practices. These studies identified areas of water conservation potential, and appropriate water conservation techniques. The Department has determined that the findings from these studies still apply to current industrial use practices. In addition, a 1996-97 Tucson AMA study, funded by a conservation assistance grant, investigated water use practices at cooling towers and yielded additional information on water conservation potential for those facilities (Conservation Assistance Grant CA95TU(E)I16-00).

The following techniques are recommended for achieving water conservation in the industrial sector:

- Reusing or recycling water
- Avoiding single-pass cooling unless the water is reused
- Use of low flow plumbing fixtures
- Use of low water use landscaping with efficient irrigation systems
- Developing site-specific water conservation plans for large facilities

Most of these techniques are included in the conservation requirements for all industrial users detailed below. They apply to other industrial users as well as industrial users subject to conservation requirements for their specific type of water use. The Third Management Plan requirements are intended to send a strong conservation message to all industrial users to use water efficiently.

The Department also inventoried the other industrial user category during the planning process for the Third Management Plan to determine if any user groups with sufficient usage and conservation potential to warrant specific conservation requirements existed. The diverse nature of water uses within this category makes it difficult to formulate volumetric conservation requirements that address the various types of industries. There are, however, some opportunities for water conservation. The greatest conservation potential within the other industrial users category is in cooling and landscape watering, which are uses common to most facilities. Commercial landscapes are usually maintained by contractors whose priority is a lush appearance and who may not adjust automatic irrigation controller clocks to match weather conditions. Smaller cooling towers may not be managed as efficiently as larger towers, nor with water conservation as high a priority.

6.2.4 All Industrial Users Conservation Program

The program for all industrial users during the third management period is similar to the Second Management Plan program. All industrial users are required to avoid waste and to make diligent efforts to recycle water. Single-pass cooling or heating is not allowed unless the water is reused, and low-flow plumbing fixtures must be used as required by the state or local plumbing code. Since January 1, 1994, the Arizona Statewide Plumbing Code has required the use of low-flow fixtures in new construction throughout the state, and some local plumbing ordinances have even more stringent standards.

Two landscaping requirements are included for the third management period. For an industrial user not regulated as a turf-related facility, there is a requirement to use low water use landscape plants for landscaping where feasible, and to water with efficient irrigation systems. Improving irrigation efficiency can be a source of major water savings whether the plants have high or low water needs. The Department encourages all facilities to irrigate efficiently regardless of the type of vegetation planted. In addition, industrial users are prohibited from serving groundwater to vegetation planted in a public right-of-way after January 1, 2002, unless the plants are listed in Appendix 5-L, Low Water Use/Drought Tolerant Plant List for the Phoenix AMA, and are prohibited from serving groundwater to a water feature in the right-of-way if installed after January 1, 2002.

6.2.5 Industrial Conservation Requirements and Monitoring and Reporting Requirements for All Industrial Users

6-201. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-202 through 6-203 of this chapter shall have the following meanings:

1. *"Industrial process purposes" means water that is used by an industrial user directly in the creation or manufacture of a product.*

2. *"Industrial use" means a non-irrigation use of water not supplied by a city, town, or private water company, including animal industry use and expanded animal industry use.*

3. *"Industrial user" means a person who uses water for industrial uses.*

4. *"Low-flow plumbing fixture" means a lavatory faucet, lavatory faucet replacement aerator, kitchen faucet, kitchen faucet replacement aerator, shower head, urinal, water closet, or evaporative cooler designed to meet the use rates specified in A.R.S. § 45-312 and 313 or the applicable county or city code, whichever is more restrictive.*

5. *"Single-pass cooling and heating" means the use of water without recirculation to increase or decrease the temperature of equipment, a stored liquid, or a confined air space.*

6. *"Wastewater" means water that is discharged after an industrial or municipal use, excluding effluent.*

6-202. Conservation Requirements

Beginning on January 1, 2002 or upon commencement of water use, whichever is later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user shall comply with the following requirements:

1. *Avoid waste; use only the amount of water from any source, including effluent, reasonably required for each industrial use; and make diligent efforts to recycle water.*

2. *Do not use water for non-residential single-pass cooling or heating purposes unless the water is reused for other purposes.*

3. *Use low-flow plumbing fixtures as required by Title 45, Chapter 1, Article 12, Arizona Revised Statutes, or any applicable county or city code, whichever is more restrictive.*

4. *Use plants from the Low Water Use/Drought Tolerant Plant List, Phoenix AMA (Appendix 5-L), or any modifications to the list, for landscaping to the maximum extent feasible and water with a water efficient irrigation system. An industrial user regulated as a turf-related facility under sections 6-301, et seq., or as a new large landscape user under section 6-901, et seq., is exempt from this requirement.*

5. *Do not serve or use groundwater for the purpose of watering landscaping plants planted on or after January 1, 2002 within any publicly owned right-of-way of a highway, street, road, sidewalk, curb, or shoulder which is used for travel in any ordinary mode, including pedestrian travel, unless the plants are listed on the Low Water Use/Drought Tolerant Plant List, Phoenix AMA (Appendix 5-L), or any modifications to the list. The director may waive this requirement upon request from the industrial user if a waiver of this requirement is in the public interest. This requirement does not apply to any portion of a residential lot that extends into a publicly owned right-of-way.*

6. *Do not serve or use groundwater for the purpose of maintaining water features, including fountains, waterfalls, ponds, water courses, and other artificial water structures, installed after January 1, 2002 within any publicly owned right-of-way of a highway, street, road, sidewalk, curb, or shoulder that is used for travel in any ordinary mode, including pedestrian travel. The director may waive this requirement upon request from the industrial user if a waiver of this requirement is in the public interest. This requirement does not apply to any portion of a residential lot that extends into a publicly owned right-of-way.*

6-203. Monitoring and Reporting Requirements

A. Requirements

For calendar year 2002 or the calendar year in which the facility first begins to use water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user shall, except as provided for in subsection B of this section, include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water by source, including effluent, withdrawn, diverted, or received during the calendar year for industrial process purposes, as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

2. *The total quantity of water by source, including effluent, withdrawn, diverted, or received during the calendar year for purposes other than industrial process purposes listed in paragraph 1 of this subsection, as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

3. *An estimate of the quantity of wastewater generated during the calendar year.*

4. *An estimate of the quantity of wastewater recycled during the calendar year.*

5. *A description of the primary purposes for which water from any source, including effluent, is used.*

6. *The number of acres of land that were planted with low water use plants during the calendar year as a result of removal of plants not on the Low Water Use/Drought Tolerant Plant List, Phoenix AMA (Appendix 5-L), or any modifications to the list, if more than one acre, and the method of irrigation for those acres. An industrial user regulated as a turf-related facility under sections 6-301, et seq., or as a new large landscape user under section 6-901, et seq., is exempt from this requirement.*

B. Exemption

An industrial user who holds a Type 1 or Type 2 non-irrigation grandfathered right or a groundwater withdrawal permit in the amount of 10 or fewer acre-feet per year is exempt from the requirements set forth in subsection A of this section, unless the industrial user holds more than one such right or permit in the aggregate amount of more than 10 acre-feet per year and withdraws more than 10 acre-feet of water during the calendar year pursuant to those rights or permits.

6-204. Remediated Groundwater Accounting for Conservation Requirements

A. Accounting

Groundwater withdrawn pursuant to an approved remedial action project under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Title 49, Arizona Revised Statutes, and used by a person subject to a conservation requirement established under this chapter, shall be accounted for consistent with the accounting for surface water for purposes of determining the person's compliance with the conservation requirement, subject to the provisions of subsections B through D of this section.

B. Amount of Groundwater Eligible for Accounting

For each approved remedial action project, the annual amount of groundwater that is eligible for the remediated groundwater accounting provided in subsection A of this section is the project's annual authorized volume. The annual authorized volume for a remedial action project approved on or after June 15, 1999 is the maximum annual volume of groundwater that may be withdrawn pursuant to the project, as specified in a consent decree or other document approved by the United States Environmental Protection Agency (EPA) or the Arizona Department of Environmental Quality (ADEQ). The annual authorized volume for a project approved prior to June 15, 1999 is the highest annual use of groundwater withdrawn pursuant to the project prior to January 1, 1999, except that if a consent decree or other document approved by the EPA or ADEQ specifies the maximum annual volume of groundwater that may be withdrawn pursuant to the project, the project's annual authorized volume is the maximum annual volume of groundwater specified in that document. The director may modify the annual authorized volume for a remedial action project as follows:

1. *For an approved remedial action project associated with a treatment plant that was in operation prior to June 15, 1999, a person may request an increase in the annual authorized volume at the same time the notice is submitted pursuant to subsection C of this section. The director shall increase the annual authorized volume up to the maximum treatment capacity of the treatment plant if adequate documentation is submitted to the director demonstrating that an increase is necessary to further the purpose of the remedial action project and the increase is not in violation of the consent decree or other document approved by the EPA or ADEQ.*

2. *A person may request an increase in the annual authorized volume of an approved remedial action project at any time if it is necessary to withdraw groundwater in excess of the annual authorized volume to further the purpose of the project. The director shall increase the annual authorized volume up to the maximum volume needed to further the purpose of the project if adequate documentation justifying the increase is submitted to the director and the increase is not in violation of the consent decree or other document approved by the EPA or ADEQ.*

3. *The director shall modify the annual authorized volume of an approved remedial action project to conform to any change in the consent decree or other document approved by the EPA or ADEQ if the person desiring the modification gives the director written notice of the change within thirty days after the change. The notice shall include a copy of the legally binding agreement changing the consent decree or other document approved by the EPA or ADEQ.*

C. *Notification*

To qualify for the remediated groundwater accounting provided in subsection A of this section, the person desiring the accounting must notify the director in writing of the anticipated withdrawal of groundwater pursuant to an approved remedial action project under CERCLA or Title 49, Arizona Revised Statutes, prior to the withdrawal. At the time the notice is given, the person desiring the accounting must be using remediated groundwater pursuant to the approved remedial action project or must have agreed to do so through a consent decree or other document approved by the EPA or ADEQ. The notice required by this subsection shall include all of the following:

1. *A copy of a document approved by ADEQ or the EPA, such as the Remedial Action Plan (RAP), Record of Decision (ROD) or consent decree, authorizing the remediated groundwater project. Unless expressly specified in the document, the person shall include in the notice the volume of groundwater that will be pumped annually pursuant to the project, the time period to which the document applies, and the annual authorized volume of groundwater that may be withdrawn pursuant to the project.*

2. *The purpose for which the remediated groundwater will be used.*

3. *The name and telephone number of a contact person.*

4. *Any other information required by the director.*

D. *Monitoring and Reporting Requirements*

To qualify for the remediated groundwater accounting for conservation requirements as provided in subsection A of this section, groundwater withdrawn pursuant to the approved remedial action project must be metered separately from groundwater withdrawn in association with another groundwater withdrawal authority for the same or other end use. A person desiring the remediated groundwater accounting for conservation requirements shall indicate in its annual report under A.R.S. § 45-632 the volume of water withdrawn and used during the previous calendar year that qualifies for the accounting.

6.3 TURF-RELATED FACILITIES

A turf-related facility is any facility, including schools, parks, cemeteries, golf courses, or common areas within a housing subdivision, with ten or more acres of water-intensive landscaped area. Turf-related facilities regulated under the Industrial Conservation Program obtain groundwater pursuant to Type 1 or Type 2 non-irrigation grandfathered rights or groundwater withdrawal permits. In addition, a large number of turf-related facilities are served groundwater by municipal water providers and are also subject to the conservation requirements set forth in this section through provisions of the Municipal Conservation Program (see Chapter 5). These municipally served facilities are called individual users.

Second Management Plan conservation requirements and other factors have driven changes in the water use patterns of turf-related facilities. New facilities are designed with less water-intensive acreage, both existing and new facilities employ technology that applies water more efficiently, and facility management has become more cognizant of the need for water conservation.

6.3.1 Water Use by Turf-Related Facilities

Turf-related facilities apply water for growing turfgrass and other landscaping plants and for filling and maintaining water levels in bodies of water. Water application efficiency is determined by the type of water application system that is utilized, maintenance of the system, water application scheduling, site topography, soil type, weather conditions, and water quality. In the Phoenix AMA, 393 turf-related facilities (both industrial users and individual users) exist, including golf courses, parks, schools, cemeteries, common areas of residential developments, and other miscellaneous facilities.

A direct relationship exists between the number of acres of water-intensive landscaping being maintained within a facility and a facility's water use. In 1995, turf-related facilities in the Phoenix AMA encompassed a total of 20,400 acres of turf and 2,100 acres of water surface area. From 1989 through 1995, the average annual water application rate on turf acres within turf-related facilities ranged between 3.9 and 5.1 acre-feet per acre. Golf courses tend to be the largest turf-related facilities, typically having at least 80 acres of turf. Parks and schools make up the majority of the smaller turf-related facilities, usually having less than 30 turf acres. Water use for maintaining bodies of water is higher than for maintaining turf and low water use landscaping because evaporation from the water surface (approximately 6.2 acre-feet per acre per year) is higher than the consumptive use and evaporation rates for plants. Unlined or inadequately sealed water bodies can lose significant volumes of water through seepage. The bodies of water associated with turf-related facilities are most often constructed on golf courses, although numerous residential developments and a few parks feature bodies of water. In 1995, turf-related facilities in the Phoenix AMA maintained a total of 1,450 acres of low water use landscaping that was irrigated with a permanent watering system, such as a drip irrigation system. Application rates for this type of landscaping are much lower than for turfgrass.

"Water use efficiency" refers to the relationship between the physiological needs of the plants being watered and the amount of water actually applied. Turf-related watering is normally expressed in terms of acre-feet per acre per year. Average turf application rates at turf-related facilities may be estimated by subtracting the estimated water use for low water use landscaping and water surface area (calculated by multiplying the number of acres of low water use landscaping and water surface area by the application rates of 1.5 acre-feet per acre and 6.2 acre-feet per acre, respectively) from the total water use and then dividing the remaining water use by the total acres of turf. In 1995, the estimated turf application rates for different types of facilities in the Phoenix AMA varied from 3.3 to 8.0 acre-feet per acre per year. This range is indicative of the broad spectrum of water use patterns among the types of turf-related facilities. Parks and schools tend to have the lowest application rates, while golf courses and common areas of housing developments tend to have the highest rates. Facility acreage attributes and water application rates are detailed in Table 6-1.

Turf-related facility water use in the Phoenix AMA has increased from over 87,700 acre-feet in 1987 to nearly 97,200 acre-feet in 1995. While total water use has increased, it continues to remain below the cumulative management plan maximum annual water allotment of over 108,000 acre-feet for turf-related facilities.

TABLE 6-1
1995 ACREAGE AND WATER USE BY TURF-RELATED FACILITIES
(INDUSTRIAL USERS AND MUNICIPAL INDIVIDUAL USERS)
PHOENIX ACTIVE MANAGEMENT AREA

Turf-related Facilities		Acreage			Water Application	
Type	Number	Turf	Water Surface Area	Low Water Use Landscaped Area	Total Water Use (Acre-Feet)	Estimated Turf Application Rate (acre-feet/acre)[1]
Golf Courses	129	14,545	819	1,146	68,639	4.5
Parks	86	1,947	139	44	7,238	3.4
Cemeteries	13	418	3	1	1,531	3.6
Common Areas	29	541	1,139	226	10,468	8.0
Schools	124	2,602	0	13	7,806	3.3
Miscellaneous	13	332	45	22	1,468	4.5
Total[2]	**393**	**20,394**	**2,145**	**1,450**	**97,151**	**4.3**

1 Average application rates for turf acres were derived by subtracting the estimated water use of water surface area and low water use landscaped area from the reported 1995 water use and dividing by the number of turfed acres reported on 1995 water use reports.

2 Numbers may not add up exactly due to rounding.

Turf-related facility water demand is met through various sources, including:

- Groundwater pumped pursuant to Type 1 and Type 2 non-irrigation grandfathered rights, pumped pursuant to groundwater withdrawal permits, served by municipal water providers, or delivered by irrigation districts;
- Surface water served by municipal water providers, delivered by irrigation districts, or diverted pursuant to surface water rights;
- Effluent served by municipal providers or delivered by private sources;
- CAP water served by a municipal water provider, delivered by an irrigation district, delivered by the CAWCD pursuant to a CAP subcontract, or by any other agreement; and
- Effluent or CAP water stored underground and recovered pursuant to water storage (recharge) credits.

Turf-related facilities may use a single source or multiple sources of water. It is not unusual for a turf-related facility to receive multiple sources of water from multiple water rights or providers.

Since 1989, groundwater has remained the single largest source of water for turf-related facilities, followed by surface water, CAP water, and effluent (see Figure 6-2). Surface water and groundwater use has not increased significantly in recent years, while there has been increased use of CAP water and effluent.

FIGURE 6-2
WATER SOURCES FOR TURF-RELATED FACILITIES, 1995
PHOENIX ACTIVE MANAGEMENT AREA

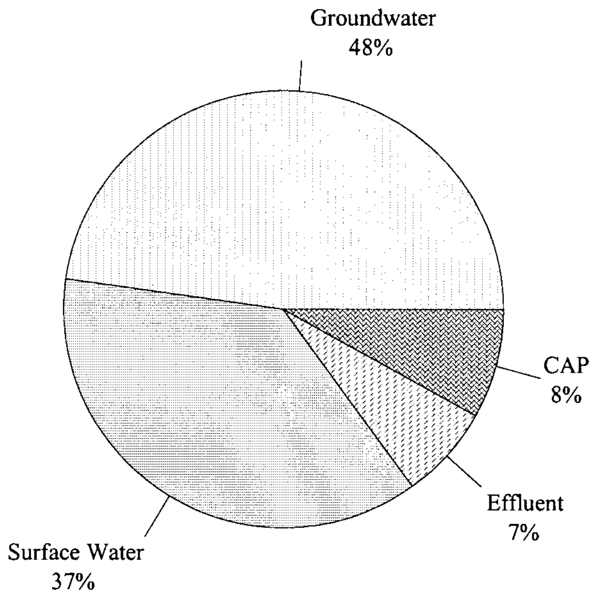


Table 6-2 further breaks down how different water sources are used by different types of turf-related facilities. Golf courses account for most of the groundwater used by turf-related facilities. However, of all the effluent and CAP water used by turf-related facilities, most is used by golf courses. Municipal providers have targeted golf courses for expanding their deliveries of these sources. Most schools and parks are located on lands with water served by a municipal provider and are less dependent on groundwater pumping for their use.

The high proportion of groundwater use by golf courses is explained in part by the fact that a majority of golf courses are industrial groundwater right or permit holders (see Table 6-3). By contrast, a clear majority of schools and parks are served by municipal providers or irrigation districts, who are more likely to have access to non-groundwater sources.

Annual water demand by turf-related facilities, whether pumped, received pursuant to grandfathered groundwater rights or groundwater withdrawal permits, or delivered by municipal water providers, will grow from over 97,000 acre-feet in 1995 to between 163,000 and 179,000 acre-feet by 2025 (163,000 acre-feet assuming Third Management Plan requirements are met, 179,000 acre-feet assuming current use trends continue). Most of the increase is projected to come from new golf courses, with the number of courses projected to more than double to 268 by the year 2025. Golf course projections are tied to the projected development patterns of subregional areas of the AMA. Water use by park, common area, and miscellaneous facilities is projected to grow commensurate with population. Although school construction will likely correlate to population growth as well, most new schools are expected to be designed with minimal turf and will not qualify as turf-related facilities. School and cemetery water use is projected to grow slowly. As has been the trend since 1985, most future golf courses are projected to be served by municipal water providers. The same is true for new parks and schools. Deliveries of effluent and CAP water to these facilities are anticipated to become increasingly prevalent in the future.

TABLE 6-2
1995 TURF-RELATED FACILITY WATER USE
BY FACILITY TYPE AND WATER SOURCE
(INDUSTRIAL USERS AND MUNICIPAL INDIVIDUAL USERS)
PHOENIX ACTIVE MANAGEMENT AREA

Type	Groundwater	Surface Water	Central Arizona Project	Effluent	Total[1]
Golf Courses	39,239	16,275	7,410	5,715	68,639
Parks	1,150	5,884	4	200	7,238
Cemeteries	741	791	0	0	1,531
Common Areas	4,137	5,189	0	1,142	10,468
Schools	1,010	6,796	0	0	7,806
Miscellaneous	276	1,025	168	0	1,468
Total[1]	**46,554**	**35,959**	**7,582**	**7,056**	**97,151**

[1]Numbers may not add up due to rounding.

TABLE 6-3
TURF-RELATED FACILITY WATER USE
MUNICIPALLY SERVED INDIVIDUAL USERS VERSUS INDUSTRIAL USERS
PHOENIX ACTIVE MANAGEMENT AREA

Turf-related Facilities	Number of Facilities		Water Use (1995)	
Type	Municipal	Industrial	Municipal	Industrial
Golf Courses	60	69	27,609	41,030
Parks	81	5	6,333	905
Cemeteries	6	7	674	857
Common Areas	13	16	4,814	5,655
Schools	115	9	7,393	413
Miscellaneous	9	4	1,102	366
Total	**284**	**110**	**47,924**	**49,227**

6.3.1.1 Golf Courses

In the Phoenix AMA, golf courses include 9-hole to 72-hole facilities. Golf courses are the largest turf-related facilities, usually having more than 80 acres of water-intensive landscaping. Non-regulation courses are shorter than 6,200 yards in total length while regulation courses are longer than 6,200 yards in total length and have 18 or more holes. Generally, non-regulation courses have less turfed acres than regulation courses. Golf courses are composed of tees, greens, fairways, and roughs. The most frequently used types of warm season grass are common or hybrid bermuda grass (*Cynodon*) with hybrid bermuda or bent grass (*Agrostis*) used primarily on greens. All golf courses overseed their tees and greens with rye grass (*Lolium*) in winter unless they have bentgrass greens. During the 1990s, some golf courses began using lower water use grass species buffalo grass (*Buchloe*) and experimenting with species such as curly mesquite grass (*Hilaria*) and purple three-awn (*Aristida*) in rough areas as a water conservation measure. A high proportion of resort golf courses overseed at least the fairways during the winter months. There is a great deal of variability in overseeding patterns on public and private courses. Some courses in the AMA prefer to avoid the expense, maintenance, and stress to the turf associated with overseeding the fairways. Some golfers appreciate the better playability associated with dormant Bermuda grass. Other facility managers feel strongly that a green appearance in the winter months is required to attract visitors to golf courses in Arizona. There is a strong emphasis on turf appearance for all golf courses, particularly resort courses and those associated with housing developments, which places a premium on aesthetics rather than maximum playability and water conservation during the winter.

Golf course water application systems are often more sophisticated than those at other turf-related facilities. Most have a system with a control panel and field satellites that can override the central controller. Computerized controlled irrigation systems and pump stations with flexibility in operating sprinkler heads are now commonplace; newer systems provide much greater savings in energy and water costs than water delivery systems from ten years ago. Most of the newer systems can incorporate weather stations, which assist in scheduling water application to more accurately replace the amount of water lost through evaporation and transpiration. Most courses apply water to greens and tees with spray heads; larger turf areas are watered with large radius heads. Water is typically pumped into the watering system from a storage tank or a body of water that is an integral part of the golf course.

Turf managers who are knowledgeable of the capabilities of water conservation technologies and practices are critical to program effectiveness. Taking advantage of a computerized system's ability to adjust water distribution uniformity (the percentage of points within the area being watered that receive equivalent amounts of water), routinely leveling heads, and frequently verifying proper operation of all controllers and heads are all examples of prudent management.

In the Phoenix AMA, 129 golf courses were in existence in 1995. These courses used 68,639 acre-feet of water in 1995, or 71 percent of the water use by turf-related facilities that year. Sixty-nine courses are served primarily by groundwater pumped by wells pursuant to non-irrigation grandfathered rights or groundwater withdrawal permits and are therefore regulated as industrial users in this Plan. Sixty are served primarily by municipalities or other sources. Twenty courses (five municipally served and 15 industrial users) receive water from more than one source. Thirty-three golf courses in the Phoenix AMA receive water from irrigation districts, most notably Salt River Project, either as a primary or a secondary source.

The total turfed area associated with the 60 golf courses served by municipal systems in the Phoenix AMA is over 5,700 acres. Golf courses classified as industrial users have over 8,700 acres planted in turf. Over 535 acres of lakes are associated with golf courses classified as industrial users; golf courses on municipal systems contain approximately 280 acres of lakes. Twenty golf courses in the Phoenix AMA are watered with effluent, which is 8 percent of the total water use by golf courses. Thirteen courses are watered with CAP water, or nearly 11 percent of the total water use by golf courses. Many of these courses are served untreated CAP water by the City of Scottsdale with the intention of converting them to effluent use.

Golf course demand has increased slowly since 1987, even with the addition of 23 new courses. While application rates increase proportionately with evapotranspiration rates in dry, hot years, application rates do not drop off as significantly in years with lower evapotranspiration rates. The average application rate for golf courses was 4.5 acre-feet per acre per year in 1995.

6.3.1.2 Parks

Public parks maintain turf for playing surfaces, for aesthetic reasons, and for erosion control. Maintenance of public parks is usually coordinated through a central office without the presence of on-site staff on a daily basis. Parks commonly have inefficient water application systems, although newer parks are installing more efficient systems, including drip irrigation and controllers with water budgeting capacity. Large radius impact heads are frequently used. Vandalism is a significant problem, requiring specialized tamper-proof heads. Bermuda grass is usually the only species planted, with rye grass overseeding limited to a few baseball fields. Relaxed turf appearance standards allow parks to "deficit irrigate," or to apply somewhat less water than the consumptive use requirement of turf. This, combined with a lack of overseeding, permits much lower application rates than those achieved by golf courses.

In 1995, 86 parks in the Phoenix AMA were identified as turf-related facilities. Eighty-one were served primarily by municipal water providers and five were industrial users. Twenty-nine of the municipally served parks received water from more than one source, while none of the industrial use parks received water from any source other than their own wells. Municipally served parks contain a total of over 1,732 acres of turf, nearly 120 acres of lakes, and nearly 44 acres of low water use landscaping. Industrial use parks contain a total of nearly 215 acres of turf and 19 acres of lakes.

Total reported water use for parks was 7,238 acre-feet in 1995. The average water application rate for parks in the Phoenix AMA was 3.4 acre-feet per acre per year. Only 14 percent of the park demand is served by groundwater withdrawn pursuant to industrial rights; the remainder is served by municipal providers. Effluent use by parks regulated as turf-related facilities is minimal, accounting only for 3 percent of park demand. However, several new parks are served solely with effluent and are not regulated as turf-related facilities. Most of the parks in the AMA are smaller than 20 acres in size.

6.3.1.3 Schools

The main function of turf in school yards is to provide an appropriate surface for active play. School managers have determined that using low water application rates can save money without adversely impacting turf use. Bermuda grass is the only species used and is seldom overseeded. Although athletic fields tend to be maintained at a higher turf quality than the balance of school yards, relaxed appearance standards and limited overseeding allow much lower application rates than those achieved by golf courses and homeowners association common areas. Often turfed acres on school grounds are deficit irrigated without sacrificing the function of the turf.

Water application systems at schools are usually relatively inflexible. In older schools, outdated equipment, including quick coupler systems, is common. Newer facilities have in-place heads with manual or electromechanical control. Some schools have converted non-play areas to drip irrigation. Due to budget constraints, it is difficult for schools to install computerized controllers so systems are frequently operated manually.

In the Phoenix AMA, 124 schools have 10 or more acres of turf and are regulated as turf-related facilities. Adjacent elementary and middle schools that share turf areas were counted as single facilities. Nine of these schools are considered to be industrial users withdrawing water from their own wells, with an amount accounting for 5 percent of total school demand. The remaining 115 schools receive water primarily from municipal sources. Of the municipally served schools, 41 received water from more than one source, while two industrial use schools had multiple sources of water. The total turfed acreage associated with all schools is 2,602 acres; there are no associated lakes. Schools in the AMA reported using a total of 7,806 acre-feet in 1995. Water use by schools has remained fairly constant since 1987.

Turf acreage within schools is small compared to other turf-related facilities. Water application rates for turf at schools are low, with an average of 3.3 acre-feet per acre per year. None of the schools regulated as turf-related facilities in the Phoenix AMA exclusively receive effluent or CAP water for turf-related watering.

6.3.1.4 Cemeteries

Cemeteries have several unique characteristics that affect water conservation potential. Cemeteries are developed in stages and are committed to maintaining grave sites in perpetuity in a manner acceptable to clients. Interment activities also cause problems in scheduling water application. Many cemetery operators believe they need to promote an image of a quiet, cool resting place and further believe turf appearance is important to achieve that image. Turf aesthetic requirements of cemeteries are similar to those of golf courses. Because cemeteries are developed in sections, the water application system is installed as new areas are opened. The water application system in older areas is often quite different from the system in recently developed sections. The result is often a complex control system that is difficult to manage. Most cemeteries use electromechanical controllers with a large number of heads on each controller. Large radius heads or raised spray heads are frequently used to allow watering around headstones. Several facilities are now upgrading their systems and installing drip irrigation for trees and shrubs.

In 1995, thirteen cemeteries in the Phoenix AMA contained 10 or more acres of turf or other water-intensive landscaping. Six of these cemeteries were served primarily by municipal water providers while seven were industrial users, withdrawing groundwater from their own wells. Three of the 13 cemeteries received water from more than one source. The total turfed acres associated with cemeteries in the AMA was 428 in 1995. Four of the cemeteries also contained lakes as a part of the facility, totaling 2.9 surface acres.

Water use by cemeteries has remained fairly constant since 1987. Cemeteries in the Phoenix AMA have an average of 33 turf acres. Water application rates are low for cemeteries, with an average of 3.6 acre-feet per acre. Total annual water use reported by these facilities was over 1,500 acre-feet in 1995.

6.3.1.5 Common Areas

Common areas are characterized as recreational or open space areas associated with housing developments that contain 10 or more acres of water-intensive landscaping. In general, these areas are a combination of turfed areas and water bodies. In many cases, water bodies predominate the landscaping. Appearance is an overriding concern for common areas. It is a traditional view that it is necessary to have turf in common areas. When turf is planted, its appearance is deemed an important factor in attracting potential home buyers and satisfying the aesthetic concerns of existing residents. As a result, turfed areas are typically overseeded and have relatively high water application rates. However, many newer developments are being designed with little or no turf, opting for low water use landscaping instead. Examples include Mountain Park Ranch, Tatum Ranch, and Las Sendas. The attractive design and lush appearance of low water use landscaping appears to have proven a successful and desirable amenity of newer developments.

Once common areas are developed and the housing development has been built out, developers usually relinquish control of the common area to the homeowners' association. Homeowners' associations typically hire a landscape management company to maintain common areas and are not highly involved in the daily management practices of the facilities.

There are 29 common area facilities in the Phoenix AMA. Thirteen of the facilities are served primarily by municipal providers. The remaining 16 are served by their own wells. Seven of the industrial use facilities have multiple water sources; three of the municipally served common area facilities have more than one source of water. The total turfed area associated with municipally served common area facilities is nearly 237 acres. Total water surface area in these same facilities is nearly 485 acres. Common area facilities within the Phoenix AMA receiving water from their own wells have a total turfed area of nearly 304 acres and water bodies covering nearly 655 acres. Effluent accounts for nearly 11 percent of common area water use. Prior to the passage of the Lakes Bill in 1987 (A.R.S. § 45-131, *et seq.*), there was a rush to construct lakes in common areas of master-planned communities. The Lakes Bill effectively prohibits the use of most groundwater and surface water for the filling and refilling of common area lakes built after 1987. Since then, the construction of lakes for common areas has diminished. Those lakes that have been constructed since 1987 are usually filled with effluent.

Water use for common areas was reported at 10,468 acre-feet in 1995; the average application rate was 8.0 acre-feet per surface area acre per year. This rate is significantly higher than the use rates of other turf-related facilities and is caused by evaporation losses from the lakes, seepage from unlined or improperly lined lakes, the practice of overseeding turf in the fall and winter, and the general emphasis on aesthetic appearance over water use efficiency by homeowners associations.

6.3.1.6 Miscellaneous Facilities

There are 13 turf-related facilities within the Phoenix AMA that do not fit into any of the previously described categories. These facilities have been grouped into a category termed "miscellaneous turf-related facilities." This category includes industrial parks, a major international airport, and a state prison facility. With the diversity of miscellaneous facilities comes a corresponding diversity in water irrigation systems, system management, aesthetic needs for turf, and water application practices.

Four of the miscellaneous facilities are served by their own wells. Nine are served by municipal water providers. Two facilities receive water from more than one source. Total water use by miscellaneous turf-related facilities in 1995 was 1,468 acre-feet.

6.3.2 First and Second Management Plan Program Development

The First Management Plan conservation requirements established a maximum annual water allotment for each turf-related facility and stressed water use efficiency. The First Management Plan provided for the adjustment of turf application rates if effluent was used.

During the first management period, several turf-related facilities were converted from groundwater to effluent use by municipal providers. These providers began to develop effluent distribution systems and these efforts are being continued. The exclusion of direct effluent deliveries from the gallons per capita per day (GPCD) calculation in the Municipal Conservation Program and the increasing regulatory costs for discharging effluent also served as incentives for providers to serve effluent to turf-related facilities when available.

At the beginning of the first management period, water management practices such as evapotranspiration-based water application scheduling by turf-related facilities was uncommon. Due in good part to First Management Plan conservation requirements, such water management practices have become common.

Development of the Second Management Plan conservation requirements involved extensive data collection regarding water use patterns in Arizona and the conservation options available to turf-related facility managers. The Department relied heavily on input from the Turf Advisory Committees in the Tucson and Phoenix AMAs consisting of golf course, park, cemetery, and school turf managers; turf irrigation specialists; extension agents; and golf course designers.

The Department hired a consultant to analyze the water conservation practices used in the turf industry and the potential for water conservation. The study evaluated technologies, including management practices and design alternatives, associated with water conservation. A primary finding of the study was that management of the water application system, rather than the use of a specific water application system, is the most important factor in efficient landscape watering. The consultant and advisory committees concluded that a combination of good management and the latest water application systems was shown to be very effective in reducing water use.

For the Second Management Plan, the Department chose not to require specific conservation techniques due to the widely varied nature of turf-related facilities. Instead, the approach for the First Management Plan was continued and turf-related facilities were given a maximum annual water allotment. The allotment approaches of the First and Second Management Plans permitted turf managers to consider the characteristics of the facility, evaluate conservation alternatives, and decide how to most effectively apply the allotment to meet the facility's needs.

The Second Management Plan included an overall decrease in allowable application rates for all turf-related facilities, caps on maximum annual water allotments for new golf courses, a limitation on the allowable water-intensive landscaped area within new cemeteries, plus a more specific effluent incentive. In setting the annual water allotments, actual water use figures were collected from over 400 turf-related facilities in all AMAs. Data on the consumptive use of the grass species most frequently used; water application efficiency achievable with available technologies; evaporative losses from bodies of water based on pond evaporation data; management practices and technologies currently in place; conservation potential associated with additional technologies, practices, and design alternatives; and germination requirements for establishing new turf were compiled and analyzed.

Based on these factors, the Department established annual application rates in the Phoenix AMA of 4.9 acre-feet per acre for turf acres, 6.2 acre-feet per acre for bodies of water and 1.5 acre-feet per acre for low water use landscaping. Adjustments to the application rates were provided for establishing new turf, using high salinity water, filling or refilling bodies of water, and revegetating acreage disturbed during construction. For golf courses, the amount of turf acres that received 4.9 acre-feet per acre was limited to 5 acres per hole. Golf courses were given application rates of either 3.0 or 4.0 acre-feet per acre for a limited amount of turf acres in excess of 5 acres per hole.

The Department continued to encourage the use of effluent in the Second Management Plan. As an incentive, effluent use, if 50 percent or more of total water use, was discounted 15 percent to 20 percent when determining a facility's compliance with its maximum annual water allotment.

A review of short-term weather data in the 1980s indicated that a three-year averaging method would adequately compensate for weather fluctuations when determining a facility's compliance with its allotment. A provision for finding a facility in compliance on either an annual or a three-year average basis was included in the Second Management Plan.

The Second Management Plan has proven most successful in changing the design of new facilities by reducing turfed acres without sacrificing function. Water use is highly correlated with the number of turfed acres within the facilities. Recent school and park designs have usually eliminated turf except where essential for recreational purposes, thus reducing water use. Most parks and schools built during the second management period in the Phoenix AMA have less than 10 acres of water-intensive landscaping and for that reason are not regulated as turf-related facilities. Golf course designers have been able to design lower acreage courses without affecting appearance and playability. Generally, improvements in water management and irrigation technology have allowed turf-related facilities to increase the percent of acreage that is overseeded while maintaining efficient water application rates and staying within their maximum turf allotment.

Table 6-4 compares landscaping acres per hole for existing and new regulation size golf courses. Since 1985, under both the First and Second Management Plans, new courses have substantially less turf and lake acres per hole.

TABLE 6-4
AVERAGE LANDSCAPING ACRES PER HOLE, EXISTING AND NEW GOLF COURSES
PHOENIX ACTIVE MANAGEMENT AREA

Type of Acres	Existing Regulation Golf Courses (Pre-1985 Courses)	New Regulation Golf Courses (Post-1984 Courses)
Turf	6.6	4.8
Lake	0.4	0.2
Low Water Use Landscaping	0.2	1.5

Few turf-related facilities in the Phoenix AMA have had difficulty complying with their maximum annual water allotment during the second management period. Facilities that have been out of compliance with the requirements have chosen to implement long-lasting conservation technologies, such as relining of leaking bodies of water; permanent removal of turf; or the renovation of aging, inefficient watering systems.

6.3.3 Issues and Third Management Plan Program Development

The Code provides that the conservation programs for industrial users shall require the use of or shall establish conservation requirements based on the latest commercially available and economically feasible water conservation technologies. For turf-related facilities, such technologies include: (1) the use of weather-based water application scheduling and water budgeting; (2) accurate, well-designed water application systems and computerized control mechanisms; (3) golf course design that concentrates water-intensive landscaping in areas that come into play; and (4) polyvinyl chloride (PVC) liners for bodies of water. Using new low water use and drought tolerant turfgrasses, improving conservation knowledge and awareness by facility management, and converting industrial users to renewable supplies are ways turf-related facilities could further contribute to the AMA goal of safe-yield.

Technical Advisory Committees (TACs) in the Phoenix and Tucson AMAs consisting of golf course, park, school, and cemetery turf managers; golf course directors; golf course architects; industry association representatives; and land developers have contributed to the development of the Third Management Plan conservation program for turf-related facilities. The TACs aided the Department in identifying second management period water use efficiency and water supply and conservation program effectiveness issues, provided and reviewed data and information relevant to the issues, and participated in developing program alternatives for the third management period. In some cases, subcommittees were formed to address a specific issue and to make a program recommendation to the committee as a whole. These committees and the Department identified the following issues of relevance:

- The allotment methodology
- Application rates for turf
- Weather adjustment
- Renewable supply incentives

6.3.3.1 Allotment Methodology and Application Rates

The Second Management Plan annual application rates of 4.9 acre-feet per acre for turf acreage, 6.2 acre-feet per acre for bodies of water, and 1.5 acre-feet per acre for low water use landscaping applied to all turf-related facilities. However, for golf courses, the turf application rate of 4.9 acre-feet per acre per year is limited to a maximum of 5 acres of turf per golf hole. Turf acres in excess of 5 acres per hole received a lower application rate of 4.0 acre-feet per acre per year if planted prior to 1985 and 3.0 acre-feet per acre per year if planted after 1984.

The total allocation given to golf courses for turf and low water use landscaping in excess of 5 acres of landscaping per hole was subject to a cap. For regulation golf courses in existence prior to 1985, the allocation was limited to an allocation for those acres in excess of 5 acres per hole that were planted prior to 1985, or an amount calculated by multiplying 5 acre-feet by the number of holes in the facility, whichever was greater. For regulation golf courses that came into existence after 1984, the allocation was limited to an amount calculated by multiplying 5 acre-feet by the number of holes in the facility. For non-regulation golf courses in existence prior to 1985, the allocation was limited to those acres in excess of 5 acres per hole that were planted prior to 1985. Non-regulation golf courses that came into existence after 1984 received no allocation for turf and low water use landscaping in excess of 5 acres per hole.

During Third Management Plan development, some representatives of the golf industry argued that the second management period application rates for turf and the cap on the allotment for golf courses constructed after 1984 denied golf courses their legal right to sufficient groundwater to meet their actual needs consistent with their selected business practices. They felt that the Department's program unreasonably prevented the complete overseeding of golf courses, interfered with reasonable management of longer courses needed to attract high-visibility tournaments, and resulted in target-style courses that imposed unreasonable skill demands on inexperienced and older players. They asserted that the allocations were not supported by sufficient data. Other TAC members felt that Second Management Plan application rates and allotment limitations were supported by scientific research and that, while potentially challenging to superintendents and designers, the allotments were adequate assuming the use of high-quality water application systems and conscientious water management practices.

Factors influencing turf watering needs include temperature, solar radiation, humidity, wind, and soil moisture. Based on research conducted at the University of Arizona Desert Turf Research Center (Brown, Gilbert, and Kopec, 1996) and 1988 to 1996 weather data from the Arizona Meteorological Network (AZMET) Phoenix Encanto, Phoenix Greenway, and Litchfield Park Stations, high-quality turf with winter overseeding would need to be irrigated with 4.1 to 5.2 acre-feet per acre per year, depending upon the weather conditions of that year, not including rainfall. This research supports the adequacy of the Second Management Plan's 4.9 acre-feet per acre per year application rate for maintaining overseeded turf.

The research found that using water sources with certain qualities may lead to long-term root zone salt accumulation. Additional investigation is needed to determine if typical rainfall distribution will adequately flush accumulated salts that are contained in certain water sources beyond the turfgrasses' root zone or, if rainfall is not sufficient, if continuous water application at a slightly higher rate or periodic flushing at a much higher application rate would best balance salt management and water application efficiency.

When turf acres are planted in excess of 5 acres per hole at a golf course, these acres are typically used to create broader fairways and larger greens than comparable golf courses with fewer turf acres. These outlying areas are in play less frequently than turf down the center of the fairways or closer to the tees. As a result, the wear and stress on grass in outlying areas are much lower. Lower levels of wear and stress reduce water demand for the turf acres in excess of 5 acres per hole. In addition, overseeding for aesthetic concerns may not be as necessary for areas of a golf course that do not frequently come into play. These factors support the adequacy of the Second Management Plan's annual application rates of 3.0 or 4.0 acre-feet per acre for turf in excess of 5 acres per hole.

The Third Management Plan allotment methodology allows target type courses to apply water to turf at a higher application rate than the 4.9 acre-feet per acre per year rate given for turf acres. Under the Third Management Plan, some or all low water use landscaping will qualify for this application rate if the amount of turf is less than 5 acres per hole. If low water use landscaping is well designed and carefully managed to take maximum advantage of rainfall, over spray, and this generous application rate, most of the allocation that is provided for low water use acreage may be applied to turfed acres.

Historic water use and research in California indicates that the higher unirrigated perimeter to turfed acre ratios, typical of target-style courses, may result in higher water demand per acre than that of more traditionally designed courses. Increased evapotranspiration may occur within 200 feet of perimeters adjacent to unweathered or low water use areas. On narrow fairways these zones may coincide, and water demand for the entire turfed area may increase on the order of 5 percent. To sufficiently quantify this effect for possible inclusion in management plan requirements, additional research should be conducted in the desert regions of Arizona.

Because regional variation in rainfall, wind speed, soil type, root zone depth, and course topography can all have potential negative impacts on turf water demand, application rates deemed sufficient for the majority of facilities were agreed upon by the TAC. Individual facilities with special circumstances that could render these application rates unreasonable can seek relief through the administrative review process. A.R.S. § 45-575.

6.3.3.2 Weather Adjustment

Long-term weather data indicates that the mid-1980's and early 1990s represented a comparatively "wet" period. Historically, rainfall in the Phoenix AMA tends to be cyclic, with "dry" or "wet" periods that may last as long as four or five years. Wet years early in the second management period were followed by a protracted period of hot summer weather combined with sparse or late summer rains. Consequently, in 1996 and 1997, an unusually large number of turf-related facilities began to experience difficulty in complying with their annual water allotments.

Alternatives to the three-year averaging mechanism provided for determining compliance in the Second Management Plan were considered to more adequately compensate for weather fluctuations, including a flexibility account and a five-year averaging provision. For the third management period, the Department chose not to extend the three-year averaging provision to five years. The length of a five-year averaging provision would result in a considerable lag between the time the annual allotment was exceeded and when corrective action could be taken. Instead, the Department opted for a flexibility account for the third management period that contains both credit and debit limits. The account will encourage and reward careful management through the accrual of credits. Credit and debit limits for the flexibility account have been set at 20 percent of the maximum annual water allotment.

6.3.3.3 Renewable Supply Incentives

While many new facilities are served alternative water sources by municipal providers, existing industrial users continue to pump groundwater. Conservation requirements strive for efficient use but cannot eliminate the contribution to overdraft by industrial users. The availability of Type 2 non-irrigation grandfathered rights through purchase or lease, the conversion of irrigation rights to Type 1 non-irrigation grandfathered rights, the issuance of groundwater withdrawal permits, and the delivery of groundwater by municipal water providers and irrigation districts are all prospects that could increase groundwater use by turf-related facilities in the future and further increase overdraft in the Phoenix AMA.

The Phoenix AMA does not have a region-wide reclaimed water system. This constrains the ability of turf-related facilities to directly use effluent. Most of the wastewater generated in mature, developed areas of Phoenix, Glendale, Sun City, Scottsdale, Tempe, and Mesa is directed to the 91st Avenue Wastewater Treatment Plant. It is downstream from most users and much of its effluent is sent to Palo Verde Nuclear Generating Station and Buckeye Water Conservation and Drainage District. In areas of newer development, many providers appear to be moving away from this centralized system in favor of building or constructing localized wastewater treatment plants.

The cost of using renewable water supplies is a major consideration for those turf-related facilities operating their own wells because it is usually considerably cheaper to pump and use groundwater than to purchase effluent from municipal water providers. In 1997, the cost of effluent served by municipal water providers ranged from less than $100 per acre-foot to over $500 per acre-foot. While these rates are usually less than potable water service from municipal water providers, effluent rates tend to be partially subsidized by potable water sales and other revenue-generating activities.

In the Second Management Plan, the effluent use incentive was structured so that if at least 50 percent of a facility's applied water was effluent, the volume of effluent used was discounted against the allotment. The amount of the discount was 15 percent if up to 90 percent of the total water use was effluent and 20 percent if 90 percent or more of the total water use was effluent. Also, the cap placed on the allocation given for bodies of water within new golf courses did not apply to bodies of water filled entirely with effluent.

The cost and availability of effluent delivery and the policies of municipal water providers and local jurisdictions primarily determine effluent use for turf-related watering in the Phoenix AMA. In addition to reserving high-quality groundwater for potable uses, serving effluent for turf-related watering provides further community benefits. Excluding direct deliveries of effluent from a municipal provider's gallons per capita per day conservation requirement makes effluent delivery attractive to water providers. Effluent reuse also eases peak demand impact on potable water systems. Avoidance of lengthy permitting processes and treatment costs incurred when effluent is discharged into public waterways makes reuse attractive to wastewater treatment authorities. Effluent reuse can also help to reduce groundwater pumping in areas with substantial water level declines or land subsidence potential.

The Department and the Third Management Plan Turf TAC discussed several incentives that would further encourage effluent use by both municipally provided facilities and industrial users during the third management period. Because effluent is an underutilized supply, the Department chose to discount all direct effluent use by 40 percent. The incentive will provide a significant discount to encourage effluent use where supplies are expensive. It will also encourage and reward the construction of wastewater treatment plants to produce effluent in new developments where supplies may be limited until residential development nears completion. With the incentive, the Department acknowledges the need for efficient use of all water supplies, while providing a higher potential application rate to facilities using higher percentages of effluent.

The Department and the TAC also explored options to allow a turf-related facility to mitigate water use in excess of the annual water conservation allotment. If more groundwater is used at a turf-related facility than allowed by its annual water allotment, a net benefit could be provided to the aquifer either through recharging without earning credits (known as storing "non-recoverable" water) or extinguishing existing recharge credits at a higher rate than the excess groundwater used at the facility. Issues considered included the rates of recharge required, conditions to ensure no wasteful practices are condoned, the effect on water conservation efforts, and the effect of excessive pumping on localized groundwater conditions.

The Department determined that this option will not be included as a part of the conservation requirements for turf-related facilities during the third management period. In the meantime, the option of extinguishing recharge credits or storing non-recoverable water in particular areas as a compliance mechanism will be considered during the third management period, even in advance of a violation. Owners and operators of turf-related facilities who anticipate an allotment violation are encouraged to develop a proactive response program in cooperation with the Department (see Chapter 10).

6.3.4 Turf-Related Facilities Conservation Program

The conservation requirements for turf-related facilities in the third management period include a maximum annual water allotment and additional requirements, provisions to encourage reduction in turfed acres, allotment adjustments for special circumstances, and an effluent use incentive.

6.3.4.1 Maximum Annual Water Allotment

The maximum annual water allotment is composed of a base allotment and any pertinent allotment additions.

6.3.4.1.1 Base Allotment

The core of the conservation program for turf-related facilities is the maximum annual water allotment. The allotment is calculated differently depending on the type of facility, but generally there is a direct relationship between the number of acres to which water is applied and the volume of the allotment. The turf acres, water surface acres, and low water use landscaped areas are multiplied by acre-foot per acre application rates to calculate the allotment.

Allotments for turf-related facilities other than golf courses are calculated by multiplying acreage by the appropriate application rates shown in Table 6-303-1. The approach used for these facilities allows for the expansion of landscaped area.

In developing the water allotment formula for golf courses, the Department recognized that the latest conservation technology includes course design that concentrates water-intensive landscaping into areas that come into play and water management practices that adjust water application schedules for weather conditions and seasons of highest play. For pre-1985 golf courses, the allotment is based on the highest number of landscaped and water surface areas in existence at the facility between 1980 and 1984. Post-1984 golf course allotments are capped or restricted by limiting the number of landscaped acres and water surface areas for which an allotment is given. The purpose of the cap is to encourage efficient design, construction, water application, and overseeding practices.

In response to advisory committee concerns regarding the need for design flexibility of regulation courses, the Department developed separate allotment calculation methods for championship length (regulation) and non-championship length (non-regulation) golf courses. The allotment calculations for pre-1985 non-regulation and regulation length courses are shown in Tables 6-304-1 and 6-304-2, respectively, and for post-1984 non-regulation and regulation length courses in Tables 6-305-1 and 6-305-2, respectively. Pre-1985 and post-1984 golf courses may expand or develop any number of water-intensive landscaped acres. However, water use must not exceed the maximum annual water allotment, which assumes acreage restrictions. Although the allotment is calculated on a per acre basis, the facility manager has discretion on how to use the allotment within the facility.

Allotments for pre-1985 golf courses are calculated based on acres of historic turf, water surface area, and low water use landscaping. For the first 5 acres per golf hole, the application rate for turf acres is limited to 4.9 acre-feet per acre. This acreage is referred to as planted acres and may include low water use landscaping if there are less than 5 acres of turf per golf hole. Historic turf and historic low water use landscaping (acres in existence from 1980 through 1984) in excess of planted acres receive lower application rates. Any additions to existing regulation golf courses are also considered to be part of existing golf courses, but will receive still lower application rates. For the allotment in addition to the planted acres, existing championship golf courses may receive a maximum of 5 acre-feet per hole or the full allotment for historic acres, whichever is greater.

Post-1984 golf course allotments are calculated similarly to pre-1985 golf courses but with several differences. Post-1984 non-regulation length courses do not receive an allotment for turf or low water use landscaped acres in excess of planted acres. Post-1984 regulation golf courses receive an application rate for historic turf acres and historic low water use landscaped area (acres in existence from 1985 through 1989) not included in planted acres. However, the application rate is lower for historic turf than the application rate for historic turf acres within a pre-1985 golf course.

For pre-1985 golf courses, the allotment for water surface area is based on the highest number of water surface acres in existence from 1980 through 1984. The allotment for water surface area within any expanded portion of a pre-1985 golf course is capped at an amount calculated by multiplying the application rate of 6.2 acre-feet per acre by 0.14 acre per hole. For post-1984 golf courses, the allotment for water surface area is based on the highest number of water surface acres in existence within the facility from 1985 to 1989 that were entitled to an allotment under the First Management Plan or an amount calculated by multiplying the application rate of 6.2 acre-feet per acre by 0.14 acre per hole, whichever is greater. Allotments for bodies of water entirely filled and refilled with direct use effluent or effluent recovered within the area of impact are not included in the 0.14 surface acres per hole cap.

6.3.4.1.2 Allotment Additions

Under certain circumstances, a turf-related facility is entitled to an addition to its base allotment. In some cases, the allotment addition is effective only for one year; in other cases, the allotment addition is effective for a longer period. The following sections describe allotment additions allowed in the Third Management Period.

6.3.4.1.2.1 Reduction of Turfed Acreage

Conservation requirements for the third management period continue to provide an incentive to reduce water- intensive landscaped area. For pre-1985 and post-1984 golf courses, the maximum annual allotment is based on the maximum area of turf and bodies of water developed at each facility from 1980 through 1984 and from 1985 through 1989, respectively. Thus, removal of acreage planted from 1980 to 1984 for a pre-1985 golf course and from 1985 to 1989 for a post-1984 golf course will not decrease the facility's allotment. All turf-related facilities are encouraged to minimize the water-intensive landscaping to areas consistent with the intended use and enjoyment of the facility.

6.3.4.1.2.2 Allotment Addition for the Establishment of Newly Turfed Area

An allotment addition is given to turf-related facilities for the establishment of newly planted turf. The allotment addition is 1.0 acre-foot per acre of newly turfed area and is limited to the calendar year in which the turf is planted. For golf courses, the allotment addition is limited to an amount calculated by multiplying the number of holes present within the newly turfed area by 5 acre-feet of water.

6.3.4.1.2.3 Allotment Addition for Revegetation

A revegetation allotment addition is available to facilities that establish low water use or other site-adapted landscaping plants after construction or renovation and which will need only temporary supplemental water application. This allotment addition of up to 1.5 acre-feet per acre for a maximum of three calendar years is quantified and granted on an individual basis through an application process. The quantity and duration of the allotment adjustment is determined through the Department's evaluation of each application. This adjustment is separate from the low water use landscaping application rate of 1.5 acre-feet per acre included in the maximum annual water allotment calculation and is not included in the allotment caps for low water use landscaped area within golf courses.

6.3.4.1.2.4 Allotment Addition for Filling Bodies of Water

New turf-related facilities receive a one-time allotment addition to fill bodies of water within the facility. The allotment addition is equal to the volume used for initial filling of the body of water and is given only for the year in which the body of water is filled. Any facility may also apply for an allotment addition to refill a body of water which has been emptied for maintenance work to eliminate or reduce seepage losses. The allotment addition may be given only for the year in which the body of water is refilled.

6.3.4.1.2.5 Allotment Addition for Leaching

When high levels of total dissolved solids are present in the water supply, a turf-related facility may need an additional amount of water for leaching, or deep percolation, to prevent salts from accumulating in the root zone. If salts are allowed to accumulate in the soil, the salinity will eventually reach levels toxic to turfgrass. Since most water supplies in the Phoenix AMA are of a quality that does not require an additional leaching allowance, a leaching allowance was not included in the maximum annual water allotment calculation. However, if a facility's water supply has a concentration of 1,000 milligrams per liter of total dissolved solids (approximately 1.5 millimhos per centimeter of electrical conductivity) or greater, the turf-related facility may apply to the Department for an allotment addition for leaching.

6.3.4.2 Additional Conservation Requirements

All turf-related facilities are required to prepare and maintain a water conservation plan. The plan must outline the water management practices and technologies the facility will utilize to maximize water use efficiency.

Turf-related facilities that are schools, parks, or common areas are required to design, construct, and maintain grounds in a manner that will minimize water-intensive landscaped areas consistent with reasonable use and enjoyment of the facility.

A turf-related facility that is a cemetery must limit the water-intensive landscaped area within any portion of the cemetery that was neither in operation as of December 31, 1984 nor substantially commenced as of December 31, 1984 so that no more than 75 percent of the total cemetery operating area is landscaped with plants not listed on the Low Water Use/Drought Tolerant Plant List for the Phoenix AMA (see Appendix 5-L). This restriction does not apply to an expansion of a cemetery onto contiguous land that was under the same ownership as the cemetery as of December 31, 1984.

6.3.4.3 Effluent Use Adjustment

In the Phoenix AMA, effluent is the only water supply that is expected to increase in availability throughout the third management period. Effluent's high nutrient content makes it an excellent supply for turf-related watering, as long as the nutrient load is carefully matched to plant needs and over-application of potential groundwater pollutants is avoided. Despite the availability and suitability of effluent for turf watering, effluent is currently underutilized as a source of water for turf-related facilities.

To encourage the maximum use of effluent on turf-related facilities during the third management period, the Department has modified the effluent incentive offered in the Second Management Plan. While the maximum annual water allotment does not change under this incentive, each acre-foot of effluent used will be counted as 0.6 acre-foot when compliance with the maximum annual water allotment is determined. This adjustment does not apply to effluent stored in a storage facility pursuant to a water storage permit that is recovered outside the area of impact of the stored water.

6.3.4.4 Flexibility Account

To compensate for fluctuating weather conditions, each turf-related facility will have a flexibility account with credit and debit limits. In wetter years or with careful management, facilities may accrue a credit balance up to 20 percent of a facility's annual allotment. When weather conditions or water management decisions cause a facility's water use to exceed its annual allotment in any year, accrued credits are expended. If all credits are exhausted, a facility may accrue a debit balance up to 20 percent of the allotment. A violation will occur only when all credits have been exhausted and the debit maximum is exceeded. Prudent facility managers will take advantage of wet years and the latest conservation technologies to accumulate as many credits as allowed in order to compensate for fluctuations in water demand during hot or dry years.

6.3.4.5 Monitoring and Reporting Requirements

The conservation requirements for the third management period include monitoring and reporting requirements for all turf-related facilities. All turf-related facility water use will be assumed to be for landscape watering purposes unless other water uses are metered separately. For example, if water for domestic uses at a park is not metered, it will count against the facility's allotment. This provision encourages facilities to install enough meters to ensure that turf-related watering is accurately reported.

6.3.5 Non-Regulatory Efforts

During the second management period, over $16,000 was awarded under the Conservation Assistance Grant Program to assist turf-related facilities with the dissemination of turfgrass water use information. Two grants awarded to the University of Arizona provided funding for continuation of the Phoenix AZMET Node (PAN), which is a free public access computer bulletin board system operating in the City of Phoenix Water Conservation Office. The PAN provides access to a variety of information, including weather data for the Phoenix area, reference and turf evapotranspiration data, and lawn watering guides. This information assists large turf facility operators with irrigation scheduling.

Opportunities for future research abound in turf-related water conservation, and conservation assistance funds may be used during the third management period to address several research needs. Anecdotal evidence for golf courses in central and southern Arizona suggests that target style courses may be subject to increased advective effect from adjacent desert areas. Further study is needed to quantify the potential water demand impacts of factors such as advection that may be inherent in lower acreage facility designs. New computer controlled watering systems, which isolate watering needs of specific areas of turf, could prove to be a useful source of data for verifying this phenomenon. Many computer controlled irrigation systems have been introduced into the market in the last decade. How well turf-related facility managers understand and employ the latest commercially available water application technologies is not well documented.

Long-term use of water sources high in total dissolved solids, such as effluent, may lead to the need for the application of additional water to leach or flush salts below the root zone. Quantifying the long-term implications of using these sources would enhance understanding of the effects, if any, on water application rates.

The watering needs of low water use landscaping must be precisely quantified to determine whether the annual application rate of 1.5 acre-feet per acre is appropriate. Some evidence suggests the rate may be excessive, especially after the plants have become established.

6.3.6 Future Directions

To achieve the safe-yield goal in the Phoenix AMA, a reduction in all groundwater use must occur. The current Code provisions limit the Department's ability to achieve this goal. They allow continuing withdrawal of groundwater by existing users, as well as additional withdrawals by new industrial users. Management plan conservation requirements can reduce groundwater pumping by industrial users only to the extent that the requirements are consistent with reasonable economic return. Absent additional authority specifically addressing the appropriateness of using high quality groundwater for turf-related watering, the management plans can only require water use efficiency that is economically justified.

Increased utilization of renewable water supplies combined with efforts to maximize water application efficiency become key factors in meeting the AMA's water management goals. Renewable water supply use requirements or broader groundwater use prohibitions targeting specific water uses, as in the "Lakes" Bill (A.R.S. § 45-131, *et. seq.*), are possible approaches. A change to the statutes that would allow the CAGRD to replenish mined groundwater not associated with the demonstration of an assured water supply combined with a replenishment obligation for all or a portion of mined groundwater used by turf-related facilities, would facilitate greater utilization of renewable supplies and would reduce groundwater overdraft.

The relationship of turf-related watering to groundwater overdraft must be evaluated and quantified. Approximately one-half of turf-related water demand in 1995 was met with groundwater. Although some component of applied water may be incidentally recharged, deep percolation of water that may contain fertilizers and other horticultural chemicals could lead to serious water quality issues and must not be encouraged.

Stronger conservation-oriented technology and water management practice requirements should be considered from both a regulatory and non-regulatory perspective for the fourth management period. From a regulatory perspective, application rates for turf acres and low water use landscaping acres used to calculate the maximum annual groundwater allotments need to be further scrutinized under actual field conditions. Research will also need to be conducted to quantify the effects of increased evapotranspiration by turf adjacent to low water use areas. As a result of such research, fourth management period conservation requirements may include an allotment-based requirement that is different from the method used for the second and third management periods, incorporating application rates for turf and low water use landscaping that more closely resemble efficient water use needs for different types of landscaping in actual field conditions. Required use of conservation technologies and practices should be further evaluated as a regulatory alternative to enforceable allotments. From a non-regulatory approach, legislation that increases funding for conservation, education, and augmentation could assist turf managers in implementing effective water management practices, evaluating effective water conservation technology, and constructing renewable water supply conveyance infrastructure.

Development of incentive programs should continue during subsequent management periods. If necessary, efforts to broaden participation in water storage and recovery options could continue, as well as renewable supply utilization incentives. Providing additional assistance and education for increased water management efficiency must be a priority to reduce the demand side of the safe-yield equation.

6.3.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Turf-Related Facilities

6-301. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes and section 6-101 of this chapter, unless the context otherwise requires, the following words and phrases used in sections 6-301 through 6-306 of this chapter shall have the following meanings:

1. *"Additional low water use landscaped area" means:*

   a. *For a pre-1985 golf course that is a regulation golf course, low water use landscaped area that was added to the facility after December 31, 1984 and that is not included in the facility's planted acres.*

   b. *For a post-1984 golf course that is a regulation golf course, low water use landscaped area that was added to the facility after January 1, 1990 and that is not included in the facility's planted acres.*

2. *"Additional turf acres" means:*

   a. *For a pre-1985 golf course that is a regulation golf course, turf acres that were added to the facility after December 31, 1984 and that are not included in the facility's planted acres.*

   b. *For a post-1984 golf course that is a regulation golf course, turf acres that were added to the facility after January 1, 1990 and that are not included in the facility's planted acres.*

3. *"Body of water" means a constructed body of water or interconnected bodies of water, including a lake, pond, lagoon, or swimming pool, that has a surface area greater than 12,320 square feet when full and that is filled or refilled primarily for landscape, scenic or recreational purposes, or regulatory storage.*

4. *"Common area" means an area or areas that is owned and operated as a single integrated facility and that is used for recreational or open space purposes. A common area is maintained for the benefit of the residents of a housing development.*

5. *"Contiguous" means in contact at any point or part of the same master-planned community. Two parcels of land are contiguous even if they are separated by one or more of the following: a road, easement, or right-of-way.*

6. *"Direct use effluent" means effluent transported from a facility regulated pursuant to Title 49, Chapter 2, Arizona Revised Statutes, to an end user. Direct use effluent does not include effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes.*

7. *"Effluent recovered within the area of impact" means effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes, and recovered within the stored effluent's area of impact. For purposes of this definition, "area of impact" has the same meaning as prescribed by A.R.S. § 45-802.01.*

8. *"Golf course" means a turf-related facility used for playing golf with a minimum of nine holes and including any practice areas.*

9. *"Historic low water use landscaped area" means:*

   a. *For a pre-1985 golf course, the highest number of acres of low water use landscaped area in existence within the facility during any one calendar year from 1980 through 1984.*

   b. *For a post-1984 golf course, the highest number of acres of low water use landscaped area in existence within the facility during any one calendar year from 1985 through 1989.*

10. *"Historic total water surface area" means:*

    a. *For a pre-1985 golf course, the highest number of acres of total water surface area, excluding the surface area of any bodies of water entirely filled and refilled with effluent, which were in existence within the facility during any one calendar year from 1980 through 1984, plus the lesser of: (1) the number of acres of total water surface area, excluding the surface area of any bodies of water entirely filled and refilled with effluent, in existence within any portion of the facility that was expanded after December 31, 1984 and (2) an area calculated by multiplying the number of holes located within any portion of the facility that was expanded after December 31, 1984 by .14 acre per hole.*

    b. *For a post-1984 golf course, the highest number of acres of total water surface area, excluding the surface area of any bodies of water entirely filled and refilled with effluent, which were in existence within the facility during any one calendar year from 1985 through 1989 and that were entitled to an allotment of water under the management plan for the first management period.*

11. *"Historic turf acres" means:*

    a. *For a pre-1985 golf course, the highest number of acres of turf acres within the facility during any one calendar year from 1980 through 1984.*

    b. *For a post-1984 golf course, the highest number of acres of turf acres within the facility during any one calendar year from 1985 through 1989.*

12. *"Hole" means a component of a golf course consisting at a minimum of a tee and a green. A practice area or driving range is not a hole.*

13. *"Landscape watering" means the application of water from any source, at a turf-related facility to a water-intensive landscaped area, a low water use landscaped area, and revegetation acres.*

14. *"Low water use landscaped area" means an area of land at least one acre in aggregate, which is located in a turf-related facility, which is watered by a permanent water application system within the landscaped area, and planted primarily with plants listed in Appendix 5-L, Low Water Use/Drought Tolerant Plant List, Phoenix AMA, or any modifications to the list. Mature vegetation planted in a low water use landscape area must cover at least 50 percent of the area.*

15. *"Newly turfed area" means, for a calendar year, an area of land planted with a warm-season grass species that was not planted with a warm-season grass species during the preceding calendar year.*

16. *"Overseeded area" means an area of land planted during the calendar year in question with a cool season grass species that grows over dormant warm season grasses during the fall/winter period.*

17. *"Planted acres" means the total turf acres and low water use landscaped area of a golf course, up to a maximum of 5 acres per hole. In determining a facility's planted acres, turf acres shall be counted first.*

18. *"Post-1984 golf course" means either of the following:*

    a. *A golf course that was neither in operation as of December 31, 1984 nor substantially commenced as of December 31, 1984.*

    b. *A golf course that was either in operation as of December 31, 1984 or substantially commenced as of December 31, 1984 and that was substantially modified after December 31, 1984.*

19. *"Pre-1985 golf course" means a golf course that was either in operation as of December 31, 1984 or substantially commenced as of December 31, 1984 and includes any expanded portion of the golf course. If a pre-1985 golf course is substantially modified after December 31, 1984, it becomes a post-1984 golf course.*

20. *"Regulation golf course" means a golf course of at least 18 holes that is 6,200 yards or more in length per 18 holes as measured from back of the tee ground furthest from the green down the center line of the hole to the center of the green.*

21. *"Substantially commenced as of December 31, 1984" means, with regard to the construction of a turf-related facility, that the owner or operator of the facility had obtained all pre-construction permits and approvals required by federal, state, or local governments for the facility by December 31, 1984, or had made a substantial capital investment in the physical on-site construction of the facility by December 31, 1984.*

22. *"Substantially modified" means that at least 50 percent of the water-intensive landscaped area within the turf-related facility was reconfigured.*

23. *"Total cemetery area" means an area of land being used for cemetery-related purposes, including any area of land covered by grave markers or by cemetery-related buildings, walks, pathways, and landscaping, but not including roads, parking lots, and any areas of land being held for future expansion of the cemetery.*

24. *"Total water surface area" means the total surface area of all bodies of water that are an integral part of the water-intensive landscaped area of a turf-related facility. Bodies of water used primarily for swimming purposes are not an integral part of the water-intensive landscaped area of a turf-related facility.*

25. *"Turf acres" means an area of land within a turf-related facility that is watered with a permanent water application system and planted primarily with plants not listed in*

Appendix 5-L, Low Water Use/Drought Tolerant Plant List, Phoenix AMA, or any modifications to the list.

26. *"Turf-related facility" means any facility, including cemeteries, golf courses, parks, schools, or common areas within housing developments, with a water-intensive landscaped area of 10 or more acres. Turf-related facilities include, but are not limited to, those facilities listed in Appendix 6B.*

27. *"Water-intensive landscaped area" means, for a calendar year, the turf acres and the water surface acres within a turf-related facility.*

6-302. Conservation Requirements for All Turf-Related Facilities

A. Maximum Annual Water Allotment

Beginning with calendar year 2002 or the first full calendar year after commencement of landscape watering, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility shall not withdraw, divert, or receive water for landscape watering purposes at the turf-related facility during a year in an amount that exceeds the turf-related facility's maximum annual water allotment for the year as calculated in sections 6-303 through 6-305.

B. Conservation Plan

No later than January 1, 2002 or 180 days after receiving official notice of conservation requirements, whichever occurs later, an industrial user who uses water at a turf-related facility shall prepare a conservation plan for the facility that contains an accurate and detailed description of the conservation technologies, including management practices, that are applied at the facility when water is used for landscape watering purposes. The industrial user shall maintain the conservation plan until the first compliance date for any substitute requirement in the Fourth Management Plan.

C. Limiting Water-Intensive Landscaped Area

1. *Beginning on January 1, 2002 or upon commencement of landscape watering, whichever occurs later, and continuing until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility that is not a cemetery or golf course shall design, construct, and maintain the grounds of the facility in a manner that minimizes the water-intensive landscaped area of the facility consistent with the use of the facility. All of the facility's water-intensive landscaping shall be planted in those areas directly associated with the turf-related facility's primary purposes.*

2. *Beginning on January 1, 2002 or upon commencement of landscape watering, whichever occurs later, and continuing until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility that is a cemetery shall limit the water-intensive landscaped area within any portion of the cemetery that was neither in operation as of December 31, 1984 nor substantially commenced as of December 31, 1984 so that no more than 75 percent of the total cemetery area within that portion of the cemetery is planted with plants not listed in Appendix 5-L, Low Water Use/Drought Tolerant Plant List, Phoenix AMA, or any*

modifications to the list. This requirement shall not apply to any expanded portion of a cemetery in operation as of December 31, 1984 or substantially commenced as of December 31, 1984 if the expanded portion of the cemetery was under the same ownership as the cemetery as of December 31, 1984.

6-303. *Calculation of Maximum Annual Water Allotment for Turf-Related Facilities that are not Golf Courses*

For each calendar year, the maximum annual water allotment for a turf-related facility that is not a golf course shall be calculated by multiplying the number of acres in existence within the facility during the calendar year in each of the categories listed in Table 6-303-1 by the applicable application rate for each category listed in Table 6-303-1 and then adding together the products plus any allotment additions allowed under section 6-306.

If turf acres, low water use landscaped area, or total water surface area are removed from a facility during the third management period, the maximum annual allotment for the facility shall be equal to the allotment calculated for the facility pursuant to this section as if the acres had not been removed.

TABLE 6-303-1
APPLICATION RATES FOR
TURF-RELATED FACILITIES THAT ARE NOT GOLF COURSES
From 2002 until the first compliance date for any substitute requirement in the Fourth Management Plan

Type of Landscaping:	***Application rate: (acre-feet per acre per calendar year)***
1. Turf acres	*4.9*
2. Total water surface area	*6.2*
3. Low water use landscaped area	*1.5*

6-304. *Calculation of Maximum Annual Water Allotment for Pre-1985 Golf Courses*

A. *Pre-1985 Golf Courses that are not Regulation Golf Courses*

For each calendar year, the maximum annual water allotment for a pre-1985 golf course that is not a regulation golf course shall be calculated by multiplying the number of acres in existence within the facility during the calendar year in each of the categories listed in Table 6-304-1 by the applicable application rate for each category listed in Table 6-304-1, subject to the limitations set forth in footnote 1 in that table, and then adding together the products plus any allotment additions allowed under section 6-306.

TABLE 6-304-1
APPLICATION RATES FOR PRE-1985 GOLF COURSES THAT ARE NOT REGULATION GOLF COURSES
From 2002 until the first compliance date for any substitute requirement in the Fourth Management Plan

Type of Landscaping:	***Application rate: (acre-feet per acre per calendar year)***
1. Planted acres	*4.9*
2. Historic turf acres not included in planted acres	*4.0*
3. Historic low water use landscaped area not included in planted acres	*1.5*
4. Total water surface area[1]	*6.2*

[1] In determining the number of acres of total water surface area in existence within the facility, the total surface area of all bodies of water not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact shall be limited to an area calculated by multiplying the number of holes present within the facility during the year by .14 acre per hole, or the facility's historic total water surface area, whichever is greater. For purposes of this paragraph, a body of water allowed under an interim water use permit issued pursuant to A.R.S. § 45-133 shall be deemed to be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact if the body of water will be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact after the permit expires.

B. Pre-1985 Golf Courses that are Regulation Golf Courses

For each calendar year, the maximum annual water allotment for a pre-1985 golf course that is a regulation golf course shall be calculated by multiplying the number of acres in existence within the facility during the calendar year in each of the categories listed in Table 6-304-2 by the applicable application rate for each category listed in Table 6-304-2, subject to the limitations set forth in footnotes 1, 2, and 3 in that table, and then adding together the products plus any allotment additions allowed under section 6-306.

TABLE 6-304-2
APPLICATION RATES FOR PRE-1985 GOLF COURSES
THAT ARE REGULATION GOLF COURSES
From 2002 until the first compliance date for any substitute requirement
in the Fourth Management Plan

Type of Landscaping:	***Application rate: (acre-feet per acre per calendar year)***
1. Planted acres	*4.9*
2. Historic turf acres not included in planted acres[2]	*4.0*
3. Additional turf acres[1,2]	*3.0*
4. Historic low water use landscaped area not included in planted acres[2]	*1.5*
5. Additional low water use landscaped area[1,2]	*1.5*
6. Total water surface area[3]	*6.2*

[1] *If the sum of the allotments for the facility's historic turf acres not included in planted acres (line 2) and historic low water use landscaped area not included in planted acres (line 4) exceeds an amount calculated by multiplying the number of holes present within the facility during the year by 5 acre-feet of water per hole, the application rates for the facility's additional turf acres (line 3) and additional low water use landscaped area (line 5) shall be zero.*

[2] *If the sum of the allotments for the facility's historic turf acres not included in planted acres (line 2) and historic low water use landscaped area not included in planted acres (line 4) is less than an amount calculated by multiplying the number of holes present within the facility during the year by 5 acre-feet of water per hole, the total allotment for the facility's historic turf acres not included in planted acres (line 2), historic low water use landscaped area not included in planted acres (line 4), additional turf acres (line 3) and additional low water use landscaped area (line 5) shall not exceed an amount calculated by multiplying the number of holes present within the facility during the year by 5 acre-feet of water per hole.*

[3] *In determining the number of acres of total water surface area in existence within the facility, the total surface area of all bodies of water not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact shall be limited to either an area calculated by multiplying the number of holes present within the facility during the year by .14 acre, or the facility's historic total water surface area, whichever is greater. For purposes of this paragraph, a body of water allowed under an interim water use permit issued pursuant to A.R.S. § 45-133 shall be deemed to be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact if the body of water will be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact after the permit expires.*

6-305. Calculation of Maximum Annual Water Allotment for Post-1984 Golf Courses

A. Post-1984 Golf Courses that are not Regulation Golf Courses

For each calendar year, the maximum annual water allotment for a post-1984 golf course that is not a regulation golf course shall be calculated by multiplying the number of acres in existence within the facility during the calendar year in each of the categories listed in Table 6-305-1 by the applicable application rate for each category listed in Table 6-305-1, subject to the limitations set forth in footnote 1 in that table, and then adding together the products plus any allotment additions as allowed under section 6-306.

TABLE 6-305-1
APPLICATION RATES FOR POST-1984 GOLF COURSES
THAT ARE NOT REGULATION GOLF COURSES
From 2002 until the first compliance date for any substitute requirement
in the Fourth Management Plan

Type of Landscaping:	***Application rate: (acre-feet per acre per calendar year)***
1. Planted acres	*4.9*
2. Historic turf acres not included in planted acres	*0.0*
3. Historic low water use landscaped area not included in planted acres	*0.0*
4. Total water surface area[1]	*6.2*

[1] In determining the number of acres of total water surface area in existence within the facility, the total surface area of all bodies of water not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact shall be limited to an area calculated by multiplying the number of holes present within the facility during the year by .14 acre per hole, or the facility's historic total water surface area, whichever is greater. For purposes of this paragraph, a body of water allowed under an interim water use permit issued pursuant to A.R.S. § 45-133 shall be deemed to be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact if the body of water will be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact after the permit expires.

B. Post-1984 Golf Courses that are Regulation Golf Courses

For each calendar year, the maximum annual water allotment for a post-1984 golf course that is a regulation golf course shall be calculated by multiplying the number of acres in existence within the facility during the calendar year in each of the categories listed in Table 6-305-2 by the applicable application rate for each category listed in Table 6-305-2, subject to the limitations set forth in footnotes 1 and 2 in that table, and then adding together the products plus any allotment additions allowed under section 6-306.

TABLE 6-305-2
APPLICATION RATES FOR POST-1984 GOLF COURSES THAT ARE REGULATION GOLF COURSES
From 2002 until the first compliance date for any substitute requirement in the Fourth Management Plan

Type of Landscaping:	***Application rate: (acre-feet per acre per calendar year)***
1. Planted acres	*4.9*
2. Historic turf acres not included in planted acres[1]	*3.0*
3. Additional turf acres[1]	*3.0*
4. Historic low water use landscaped area not included in planted acres[1]	*1.5*
5. Additional low water use landscaped area[1]	*1.5*
6. Total water surface area[2]	*6.2*

[1] The sum of the allotments for the facility's historic turf acres not included in planted acres (line 2), additional turf acres (line 3), historic low water use landscaped area not included in planted acres (line 4) and additional low water use landscaped area (line 5) shall not exceed an amount calculated by multiplying the number of holes present within the facility during the year by 5 acre-feet of water per hole.

[2] In determining the number of acres of total water surface area in existence within the facility, the total surface area of all bodies of water not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact shall be limited to an area calculated by multiplying the number of holes present within the facility during the year by .14 acre per hole, or the facility's historic total water surface area, whichever is greater. For purposes of this paragraph, a body of water allowed under an interim water use permit issued pursuant to A.R.S. § 45-133 shall be deemed to be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact if the body of water will be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact after the permit expires.

6-306. Allotment Additions

A. Newly Turfed Area Establishment Addition

For any year in which a warm-season turfgrass species is planted at a turf-related facility, the facility shall receive an allotment addition of 1.0 acre-foot of water per acre of newly turfed area. For golf courses, the newly turfed area establishment addition shall not exceed an amount calculated by multiplying the number of holes present within the newly turfed area by 5 acre-feet of water.

B. Revegetation Addition

The owner or operator of a turf-related facility may apply to the director for an allotment addition to revegetate areas within or around the facility after initial construction or renovation. The director may allow up to an additional 1.5 acre-feet of water per acre for up to three years if the following conditions apply to the acres for which the revegetation addition is sought:

1. *The plants that are planted are listed in Appendix 5-L, Low Water Use/Drought Tolerant Plant List, Phoenix AMA, or any modifications to the list, or were adapted to the site prior to construction;*

2. *The aggregate area to be watered exceeds one acre and has at least 50 percent vegetative cover at maturity;*

3. *An allotment is not provided for the revegetation area under sections 6-303, 6-304, or 6-305; and*

4. *All of the water applied is measured and reported as part of the total water use of the facility.*

C. *Body of Water Fill and Refill Addition*

1. *A turf-related facility shall receive a one-time body of water fill allotment addition equal to the volume of water used for the initial filling of any new body of water added after January 1, 2002 within the facility. The facility shall receive the allotment addition only for the calendar year in which the body of water is filled.*

2. *If a body of water at a turf-related facility is drained or partially drained to allow for repairs to reduce water losses, the owner or operator of the facility may apply to the director for an addition to the facility's maximum annual water allotment in the amount of water necessary to refill the body of water. The director shall grant the allotment addition if the director determines that drainage of the body of water was necessary to allow for repairs to reduce water losses. The facility shall receive the allotment addition only for the calendar year in which the body of water is filled.*

D. *Leaching Allotment Addition*

The owner or operator of a turf-related facility may apply to the director for an allotment addition for leaching purposes. The director shall approve the application if the water supply used for landscape watering at the facility contains at least 1,000 milligrams per liter of total dissolved solids. If the director approves an allotment addition for leaching purposes, the director shall calculate the additional allotment as follows:

$$\textbf{\textit{Leaching Allotment Addition}} = \left(\frac{1}{1 - \left(\dfrac{EC_w}{5EC_e - EC_w} \right)} - 1 \right) \times \frac{CU}{0.85}$$

Where:

Ec_w	=	*Electrical conductivity of water used*
Ec_e	=	*Tolerance of the grass species grown to the soil salinity in electrical conductivity of the soil saturation extract*
CU	=	*Consumptive use requirement for the grass species*

Any allotment addition granted under this subsection shall remain in effect until the water supply used for landscape watering at the facility contains less than 1,000 milligrams per liter of total dissolved solids or until the first compliance date for the facility's conservation requirements in the Fourth Management Plan, whichever occurs first.

6-307. ***Combined Allotments for Contiguous Facilities***

The maximum annual water allotments for contiguous turf-related facilities under one ownership or operation may be combined. All or a portion of the combined maximum water allotment may be applied to any part of the contiguous facilities.

6-308. *Nothing in this chapter shall be construed as authorizing the use of more groundwater or surface water than may be used pursuant to any groundwater or appropriable surface water rights or permits associated with the use. Nor shall this chapter be construed as authorizing the use of water from any source in any manner that violates Chapter 1 or Chapter 2 of Title 45, Arizona Revised Statutes.*

6-309. ***Compliance with Maximum Annual Water Allotment***

A. Effluent Use Adjustment

For purposes of determining compliance with the maximum annual water allotment requirement, the director shall count each acre-foot of direct use effluent or effluent recovered within the area of impact used at the facility for landscape watering purposes during the calendar year as 0.6 acre-foot of water.

B. Flexibility Account

The director shall determine if a turf-related facility is in compliance with its maximum annual water allotment through the maintenance of a flexibility account for the facility according to the following:

1. *Beginning with calendar year 2002 or the first full calendar year after commencement of landscape watering, whichever is later, a flexibility account shall be established for a turf-related facility with a beginning balance of zero acre-feet.*

2. *Following each calendar year in which groundwater is withdrawn, diverted, or received for landscape watering purposes at the facility, the director shall adjust the turf-related facility's flexibility account as follows:*

   a. *Subtract the total volume of water from any source, including effluent as adjusted under subsection A of this section used by the facility for landscape watering purposes during that calendar year, from the facility's maximum annual water allotment for that year.*

   b. *If the result in subparagraph a of this paragraph is positive, credit the flexibility account by this volume.*

   c. *If the result in subparagraph a of this paragraph is negative, debit the flexibility account by this volume.*

3. *The account balance existing in a turf-related facility's flexibility account, after the adjustment provided for in paragraph 2 of this subsection is made, shall carry forward, subject to the following limitations:*

   a. *The maximum positive account balance allowed in the flexibility account of a turf-related facility after any credits are registered pursuant to paragraph 2,* *subparagraph b of this subsection, shall be calculated by multiplying the facility's maximum annual water allotment for the calendar year for which the credits are registered by 0.2. If the account balance exceeds the maximum positive account balance after the credits are registered, the balance carried forward shall be equal to the maximum positive account balance.*

b. *The maximum negative account balance allowed in the flexibility account of a turf-related facility after any debits are registered pursuant to paragraph 2, subparagraph c of this subsection shall be calculated by multiplying the facility's maximum annual water allotment for which the debits are registered by -0.2. If the account balance exceeds the maximum negative account balance after the debits are registered, the balance carried forward shall be equal to the maximum negative account balance.*

C. Compliance Status

If the adjustment to a turf-related facility's flexibility account at the end of a calendar year as provided for in subsection B, paragraph 2 of this section causes the account to have a negative account balance which exceeds the maximum negative account balance allowed in the flexibility account for the calendar year as calculated in subsection B, paragraph 3 of this section, the industrial users who use water at the facility are in violation of the facility's maximum annual water allotment for that calendar year in an amount equal to the difference between the facility's flexibility account balance and the maximum negative balance allowed in the facility's account for that year.

6-310. Monitoring and Reporting Requirements for Turf-Related Facilities

1. *An industrial user who uses water at a turf-related facility that commences landscape watering within any new turfed acres, low water use landscaped area or water surface acres after January 1, 2002 shall submit to the director documentation of the new acres no later than 90 days after commencing of landscape watering to the new acres or receiving notice of these conservation requirements, whichever is later. The scale of the submitted documents, extent of turf acres, water surface acres, and low water use landscaped area must clearly be shown. Documentation may consist of one or more of the following:*

   a. *As-built plans certified by a registered professional such as a civil engineer, golf course designer, or landscape architect.*

   b. *Aerial photography at a scale no smaller than 1"=200'.*

   c. *A survey of the facility certified by a registered professional such as a civil engineer or land surveyor.*

   d. *Any other documentation upon approval by the director.*

2. *For calendar year 2002 or the calendar year in which landscape watering commences, whichever occurs later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirements in the Fourth Management Plan, an industrial user who uses water at a turf-related facility shall include in the annual report required by A.R.S. § 45-632 the following information:*

a. *The total quantity of water by source, disaggregated by source, including effluent, withdrawn, diverted, or received during the calendar year for landscape watering purposes at the facility, as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

b. *The total amount of effluent, disaggregated by direct use effluent, effluent recovered within the area of impact and effluent recovered outside the area of impact that was withdrawn or received during the calendar year for landscape watering purposes as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

c. *The number of acres of total water surface area within the facility during the calendar year.*

d. *The number of acres of low water use landscaped area within the facility during the calendar year.*

e. *The number of acres of turf acres within the facility during the calendar year, not including newly turf area.*

f. *The number of acres of newly turfed area within the facility during the calendar year.*

g. *The number of turf acres removed within the facility during the calendar year.*

h. *The number of acres of total water surface area added or removed within the facility during the calendar year.*

i. *The number of acres of low water use landscaped area added or removed within the facility during the calendar year.*

j. *If the facility is a golf course, the number of planted acres within the facility during the calendar year.*

k. *If the facility is a golf course, the number of acres of historic turf acres not included in planted acres within the facility.*

l. *If the facility is a golf course, the number of acres of historic low water use landscaped area not included in planted acres within the facility.*

m. *If the facility is a golf course, the number of acres of historic total water surface area within the facility.*

n. *If the facility is a golf course, the length of the course as measured from the back of each tee ground furthest from the associated green then down the center line of the hole to the center of the green.*

o. *If the facility is a regulation golf course, the number of acres of any additional low water use landscaped area within the facility during the calendar year.*

p. *If the facility is a regulation course, the number of acres of any additional turf acres, including newly turf acres, within the facility during the calendar year.*

q. The number of acres approved by the director for a revegetation addition pursuant to section 6-306, subsection B, within the facility during the calendar year.

r. The quantity of water used to fill or refill a body of water within the facility during the calendar year for which an allotment addition is sought pursuant to section 6-303, subsection B.

s. The number of acres of overseeded area within the facility during the calendar year.

t. If the facility is a golf course, the number of holes within the facility during the calendar year.

u. If the facility is a golf course, the number of holes added within newly turf area during the calendar year.

v. An estimate of the quantity of water from any source, including effluent, used for each purpose other than landscape watering purposes at the facility during the calendar year. Any water used at the facility that is not measured separately from the water used for landscape watering shall be counted by the director as water used by the facility for landscape watering for purposes of calculating the compliance with the maximum annual water allotment.

3. A single annual report may be filed for contiguous turf-related facilities that are under the same ownership or operation if the allotments for the facilities are combined pursuant to section 6-307. The annual report shall report water use and landscaped areas of the contiguous facilities as required in subsection 2 in this section.

6.4 SAND AND GRAVEL FACILITIES

6.4.1 Introduction

Sand and gravel facilities regulated under the Third Management Plan are facilities that produce sand and gravel and use more than 100 acre-feet of water from any source in a calendar year. Sand and gravel facilities include the activities of mining aggregate, mixing concrete, and producing asphaltic concrete.

6.4.2 Water Use by Sand and Gravel Facilities

In the Phoenix AMA, approximately 20 sand and gravel facilities are located along the banks of the Salt and Agua Fria Rivers. Virtually all sand and gravel facilities pump groundwater pursuant to non-irrigation grandfathered rights or groundwater withdrawal permits. In 1995, sand and gravel facilities in the Phoenix AMA held grandfathered rights and groundwater withdrawal permits with a combined annual allotment of nearly 26,200 acre-feet of groundwater. When groundwater levels are high enough that areas where the mined material (aggregate) is inundated with water, pumping and removing the water becomes necessary.

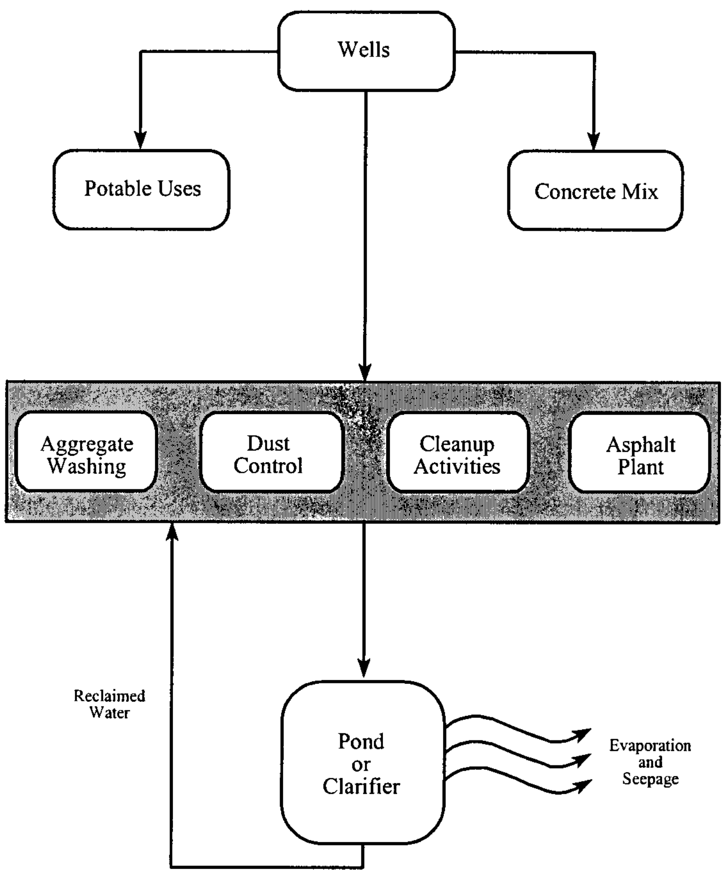
Dewatering permits authorizing the withdrawal of another 7,000 acre-feet of groundwater per year have been assigned to sand and gravel facilities in the Phoenix AMA for this purpose.

Since adoption of the Second Management Plan, operators of sand and gravel facilities have annually withdrawn between approximately 8,200 acre-feet and 13,600 acre-feet of water. It is projected that water use by sand and gravel facilities in the AMA will grow commensurate with economic activity in the AMA and will be approximately 21,800 acre-feet per year by the year 2025.

Sand and gravel facilities mine unconsolidated stream deposits to produce construction materials. The aggregate must be sorted according to grain size and washed to remove fine-grained particles. Aggregate washing accounts for the bulk of water use by sand and gravel facilities. In addition to using water for aggregate washing, water is used for the following purposes: (1) to produce ready-mix concrete, bricks, blocks, and asphaltic concrete; (2) to control dust; (3) to wash the outside of vehicles; (4) to wash the inside of mixer drums; (5) to wash other equipment; (6) to cool equipment; (7) to cool material; and (8) for domestic purposes. Figure 6-3 illustrates how water is cycled in a typical sand and gravel facility.

Most sand and gravel facilities recycle wash water using excavated pits called disposal ponds. Sediment-laden wash water is

FIGURE 6-3
DIAGRAM OF WATER FLOW IN A TYPICAL SAND AND GRAVEL FACILITY



pumped or diverted into a pit or series of pits where sediment is allowed to settle out. After this sediment settles out, the water is recycled to the plant and used to wash more material. Water can also be pumped from the pond for dust control, truck washing, or other cleaning activities.

Geologic and hydrologic conditions at many facilities may result in a large amount of seepage to incidentally recharge to the aquifer from disposal ponds. Because most facilities are located along major riverbeds, depth to groundwater is usually quite shallow. Some facilities even require dewatering to lower the water table to allow excavation to occur. Therefore, a large portion of seepage loss may become a component of the groundwater pumped by sand and gravel facilities.

An alternative method of recycling wash water is the use of clarifiers. A clarifier is a device that accelerates the settling of sediment without creating the need for a large disposal pond. Chemical flocculants are usually used in conjunction with clarifiers to further enhance the removal of solid particles from the wash water.

The ability of sand and gravel facilities to save water varies because of differences in geology, availability and cost of land and water, product demand and price, and other factors. It may therefore be economically feasible to use the latest commercially available conservation technology at some facilities but not at others. Because recycled water can be used for most purposes at a sand and gravel facility, the maximum savings of water can occur in the recycling of wash water from aggregate washing and, to a lesser extent, the recycling of water used for wet scrubbers at asphalt plants.

A number of conservation techniques may be employed to reduce the amount of water used to control dust raised by trucks traveling on haul roads. Binding agents, pavement, or other surface treatments may be used. Water used for cleanup activities may be made more efficient by metering truck washing and by using alternative methods to clean truck mixer drums. Such methods are the "rock out method," which involves agitating rock inside the mixer drums for the purpose of cleaning excess concrete, or using chemical set-arresting agents, which prevent excess concrete from adhering to the mixer drums.

Sand and gravel facilities that have asphalt plants may have air emissions from the plant cleaned by either baghouses or wet scrubbers. Of these two methods, baghouses do not require water.

6.4.3 Program Development and Issues

The First Management Plan required sand and gravel facilities to recycle wash water using disposal ponds or clarifiers. This requirement ensured that sand and gravel facilities reduced their water use. The First Management Plan requirements were carried over into the second management period.

To identify the most economical conservation methods for each facility, sand and gravel facility operators were required during the second management period to evaluate specific water saving methods and submit a conservation plan to the Department. In addition to the conservation requirements identified in the First and Second Management Plans, there are a number of economically feasible ways water use for dust control and cleanup activities can be reduced. However, because conditions and characteristics at each facility vary, flexibility is needed to allow facility operators to select the requirements most appropriate for their facility.

6.4.4 Sand and Gravel Conservation Program

The First and Second Management Plan requirements for recycling wash water are included for the third management period because implementation of recycling improves water use efficiency. All sand and gravel facilities can apply these techniques.

In addition to recycling wash water, sand and gravel facility operators must implement two additional conservation measures, one related to water used for dust control and the other related to cleanup activities. The facility operator must choose the conservation measure to be implemented in each category from a list of approved measures. The measures chosen must be the most appropriate for the facility for the third management period.

Similar to the Second Management Plan, sand and gravel operators will be required to evaluate specific water saving methods and submit a conservation plan to the Department during the third management period. The conservation plan must be submitted to the director by January 1, 2002 or within 180 days after notification of the conservation requirements, whichever is later.

Implementation of water conservation practices or technologies can result in increased profits. Sand and gravel facility operators should analyze conservation methods to identify those that will result in a positive economic return. Operators will be required to perform an economic feasibility analysis of three potential conservation practices-disposal pond surface area reduction, use of clarifiers, and the use of an alternative water supply to groundwater. The following potential costs and savings may be analyzed in the economic feasibility analysis:

- Labor (including planning, construction, operation, maintenance, and management time);
- Equipment (values amortized over the projected life of the equipment);
- Land value (including value of mineral reserves);
- Water costs (including pumping costs, well maintenance, and withdrawal taxes);
- Costs for chemicals and raw materials;
- Fuel or energy costs;
- Industrial wastewater disposal costs;
- Changes in revenue caused by changing production rates, minimizing "down-time," or increasing the size of reserves; and
- Regulatory permitting costs.

6.4.5 Future Directions

In the Phoenix AMA, sand and gravel facilities use water pursuant to non-irrigation grandfathered rights or groundwater withdrawal permits. Other potential water sources include CAP water, effluent, and poor quality groundwater, but none of these sources are currently being used by the sand and gravel industry in the AMA. Both CAP and effluent cost significantly more than groundwater and are not readily available. Groundwater pumping costs are especially low for most sand and gravel facility operators because the facilities are generally located where groundwater levels are close to the surface. In the future, sand and gravel operators may choose to increase their use of CAP water, effluent, or poor quality groundwater for many uses at the facility. The Fourth Management Plan could provide additional incentives for their use.

6.4.6 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Sand and Gravel Facilities

6-401. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-402 through 6-404 of this chapter shall have the following meanings:

1. *"Alternative water supply" means a water source other than groundwater of drinking water quality.*

2. *"Sand and gravel facility" means a facility that produces sand and gravel and that uses more than 100 acre-feet of water from any source per calendar year. For purposes of this definition, the annual water use shall include all water used by the facility regardless of the nature of the use.*

3. *"Rock out method" means agitating rock inside concrete truck mixer drums for the purpose of cleaning excess concrete from the drums.*

4. *"Wash water" means water used for washing or sorting sand, gravel, or other aggregates.*

6-402. Conservation Requirements

A. Standard Conservation Requirements

Beginning on January 1, 2002 or upon commencement of water use, whichever occurs later, and continuing thereafter until the first compliance date for any substitute conservation requirements in the Fourth Management Plan, an industrial user who uses water at a sand and gravel facility shall comply with the following conservation requirements:

1. *If sufficient land area for construction and operation of disposal ponds is available at a reasonable price, the industrial user shall construct disposal ponds at the sand and gravel facility. All wash water, all water used for wet scrubbers at asphalt plants, all runoff from cleanup operations and all drainage from sand and gravel piles shall be discharged or diverted into the disposal ponds unless prohibited by state or federal environmental regulations. The disposal ponds shall contain a barge pump or sump pump of sufficient capacity, together with any necessary additional equipment, to assure the maximum reclamation of the water. The water shall be reclaimed and reused at the sand and gravel facility unless prohibited by state or federal regulations.*

2. *If sufficient land area for the construction and operation of disposal ponds is not available at a reasonable price, clarifiers shall be used at the sand and gravel facility for reclaiming wash water, all water used for wet scrubbers at asphalt plants, runoff from cleanup operations and all drainage from sand and gravel piles. The clarifiers shall be designed and operated to assure the maximum reclamation of water. The water shall be reclaimed and reused at the sand and gravel facility unless prohibited by state or federal regulations.*

3. *At least one of the following techniques or technologies designed to reduce water use for dust control shall be implemented at the sand and gravel facility:*

    a. *The placement of binding agents on all haul roads;*

    b. *The paving of all haul roads;*

    c. *The placement of recycled asphalt on all haul roads;*

    d. *The placement of medium sized aggregate or "pea gravel" on all haul roads; or*

    e. *A technology or technique designed to reduce water use for dust control not included in subparagraphs a through d of this paragraph that demonstrates water savings equivalent to any of the technologies or techniques listed in subparagraphs a through d, and that has been approved by the director.*

    The industrial user shall have sole discretion in determining whether to implement more than one of the above technologies.

4. *At least one of the following techniques or technologies designed to reduce water use for cleaning shall be implemented at the sand and gravel facility:*

    a. *Use of metered timers for truck washing and other cleanup activities;*

    b. *Use of the "rock out method" of cleaning concrete from truck mixer drums;*

    c. *Use of concrete set-arresting agent chemical applications to clean concrete from truck mixer drums; or*

    d. *A technology or technique designed to reduce water use for cleaning that is not included in subparagraphs a through c of this paragraph that demonstrates water savings equivalent to any of the measures listed in subparagraphs a through c and that has been approved by the director.*

    The industrial user shall have sole discretion in determining whether to implement more than one of the above technologies.

B. Substitute Conservation Requirements

1. *An industrial user who uses water at a sand and gravel facility may apply to the director to use conservation technologies other than the standard conservation requirements prescribed in subsection A of this section. The director may approve the use of substitute conservation technologies if both of the following apply:*

    a. *The industrial user has submitted a detailed description of the proposed substitute technologies and the water savings that can be achieved by the use of those technologies, and*

    b. *The director determines that the proposed substitute conservation technologies will result in a water savings equal to or greater than the savings that would be achieved by the standard conservation requirements prescribed in section 6-402.*

2. *If the director approves an industrial user's request to use conservation technologies other than the standard conservation requirements prescribed in subsection A of this section, the industrial user shall comply with the substitute conservation technologies approved by the director beginning on the date determined by the director and continuing until the first compliance date for any substitute conservation requirement in the Fourth Management Plan.*

C. *Conservation Plan*

Not later than January 1, 2002 or within 180 days after receiving notice of these conservation requirements, whichever is later, an industrial user who uses water at a sand and gravel facility, including an industrial user who acquires ownership of an existing sand and gravel facility after January 1, 2002, shall submit to the director a plan to improve the efficiency of water use at the facility on a form provided by the director. The plan shall analyze the economic feasibility of implementing all of the following at the facility:

1. *Disposal pond surface area reduction.*

2. *The use of clarifiers for recycling water.*

3. *Use of an alternative water supply if such a supply is available within a one mile radius of the facility.*

6-403. *Monitoring and Reporting Requirements*

For calendar year 2002 or the calendar year in which the sand and gravel facility first commences using water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user who uses water at a sand and gravel facility shall include the following information in its annual report required by A.R.S. § 45-632.

1. *The quantity of water reclaimed from disposal ponds or clarifiers during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

2. *The quantity of water from any source, including effluent, supplied to the wash plant during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

3. *The quantity of water from any source, including effluent, supplied to the asphalt plant during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

4. *The aggregate surface area of any disposal ponds.*

5. *The average depth of any disposal ponds.*

6. *The estimated quantity of water from any source, including effluent, used during the calendar year for:*

a. Industrial process purposes. Water used for industrial process purposes includes water used for sanitary waste disposal but does not include water for cooling and cleaning purposes.

b. Non-domestic cooling purposes.

c. Non-domestic cleaning purposes. Water use for non-domestic purposes includes truck washing, truck mixer drum washing, or other non-domestic cleaning purposes.

d. Road dust control.

e. Landscape watering.

f. Other purposes.

7. The tonnage of material washed during the calendar year.

6.5 LARGE-SCALE POWER PLANTS

6.5.1 Introduction

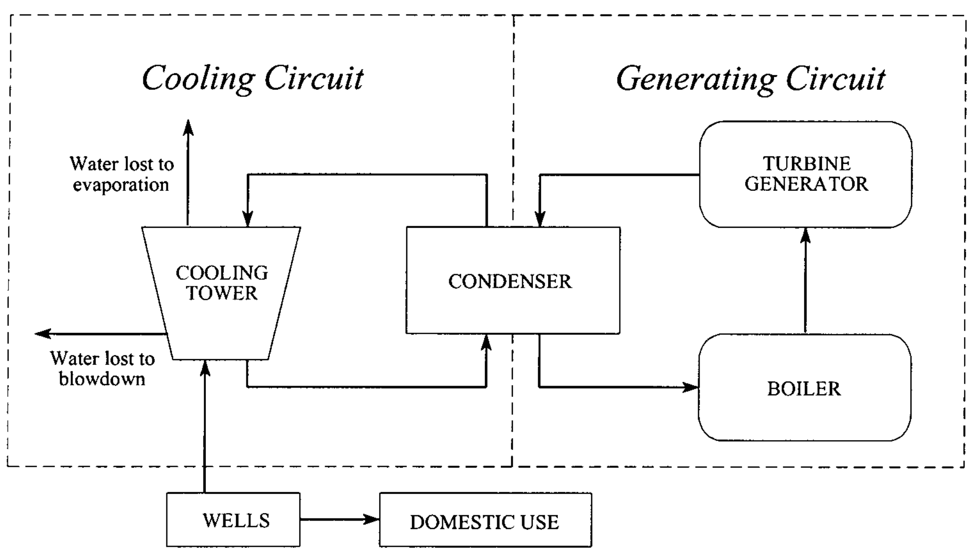
The Department regulates power plants that produce or are designed to produce more than 25 megawatts of electricity. The electric power industry uses cooling towers to dissipate excess heat that builds up in the electrical generation process. The major consumptive use of water at these facilities is evaporation from cooling towers. Because of the large volume of water used in towers, conservation requirements for the electric power industry require facilities to achieve a high level of efficiency in cooling tower operation.

6.5.2 Water Use by Large-Scale Power Plants

The electric power industry in the Phoenix AMA currently holds water rights to over 12,000 acre-feet of groundwater per year pursuant to Type 1 non-irrigation grandfathered rights and Type 2 non-irrigation grandfathered rights limited to use for electrical power generation. Four large-scale power plants (including Palo Verde Nuclear Generating Station) currently are industrial users in the Phoenix AMA. Groundwater use was over 3,830 acre-feet in 1995. While the major water source for Palo Verde is effluent and not groundwater, the other facilities rely exclusively on groundwater. Groundwater used by these plants is not projected to parallel population growth increases because power needed to meet this demand is likely to be imported, rather than generated within the AMA.

Most large-scale power plants have two water use circuits, referred to here as the generating circuit and the cooling circuit. Figure 6-4 illustrates water flow in a typical electrical power plant. In the generating circuit, water is heated in the boiler to form steam, which turns the turbines. The turbines in turn drive the generators, which create electricity. The steam must be cooled and condensed into water before being recycled back to the boiler. The conversion of water to steam and back to water in the generating circuit is completed in a closed system, so water is efficiently recycled with little loss.

FIGURE 6-4
DIAGRAM OF WATER FLOW IN A TYPICAL POWER PLANT



At the condenser, heat is transferred from the steam in the generating circuit to the cooled water in the cooling circuit. Because this heat exchange occurs through the walls of the condenser piping, water in the two circuits does not mix. The heated water in the cooling circuit is pumped to a cooling tower where it is cooled by evaporation. The cooled water is then recirculated back to the condenser. Evaporation losses in the cooling tower constitute the main consumptive use of water at large-scale power plants. As a portion of the cooling circuit water evaporates in the cooling tower, dissolved minerals become concentrated in the remaining water. Due to the high mineral concentrations, corrosion, mineral deposition, and biological fouling can result and can lead to reduced cooling efficiency and equipment damage. Use of chemical treatments can prolong water use in a tower, but periodically, mineral-laden water must be discharged or "blown down" to prevent minerals from precipitating on equipment. Replacement water, known as "make-up water," is added to replace water lost to evaporation and blowdown.

The "cycles of concentration" or "concentration ratio" achieved in a tower indicate how efficiently water is being used. Cooling towers that are consistently operated at higher cycles of concentration consume less water than towers consistently operated at lower cycles of concentration. Cycles of concentration can be determined by dividing the concentration of a constituent in the blowdown water by the concentration of this same constituent in the make-up water. Total dissolved solids content is one commonly used constituent for calculating the cycles of concentration. For example, if the total dissolved solids concentration in blowdown water is 1,500 milligrams per liter (mg/L), and the total dissolved solids content of make-up water is 300 mg/L, the tower is operating at 5 cycles of concentration. Cycles of concentration can also be calculated using electrical conductivity measurements, water volumes, and other conservative mineral constituents (mineral constituents whose concentrations are not altered by the addition of treatment chemicals).

6.5.3 Program Development and Issues

Conservation requirements for the electric power industry were generally the same in the First and Second Management Plans. Facilities in operation by the end of 1984 were required to reach 7 cycles of concentration in cooling towers before blowing down water. Facilities that went into operation after 1984 were required to reach 15 cycles of concentration. For large-scale power facilities in operation by the end of 1984, achieving 7 cycles of concentration is a realistic ceiling on water use efficiency. Above 7 cycles of concentration, the potential for additional water savings decreases while the potential for equipment damage and the cost of chemical additives both increase. Large-scale power facilities can be designed to achieve 15 cycles of concentration, but the technology to accomplish this needs to be built into the plant from the outset and represents an additional expense.

Third Management Plan regulations keep the core requirements from earlier management periods with some modifications to address cooling tower operational time periods and periods of changing water quality. In the Third Management Plan, the cycles of concentration requirement has been revised to apply only when cooling towers are in full operational mode, dissipating heat created during the generation of electricity. Some large-scale power plants generate electricity only during summer months when demand for electric power peaks. During non-generating months, compliance with the cycles of concentration requirements may not be possible because even though water is recirculated to keep tower surfaces wetted, tower evaporation fans are turned off to reduce electricity use. This reduces the normal rate of evaporation. When the recirculating water eventually becomes stagnant, it needs to be blown down even if 7 (or 15) cycles of concentration have not been reached.

Individual cooling towers are periodically shut down and rebuilt. New structural pieces may be installed in towers during this process. If chemically treated lumber is used, concentrations of arsenic, copper, and chromium may build up in tower water. This water must be discharged before these concentrations exceed environmental standards even if 7 (or 15) cycles of concentration have not been reached. As groundwater is withdrawn from greater depths, mineral and trace metal concentrations can increase. When this groundwater is used to provide make-up water to cooling towers, concentrated minerals in the recirculating water can precipitate and cause equipment damage. The potential also exists for trace metals to build up in recirculating water and exceed sewer system discharge standards for Publicly Owned Treatment Works or exceed National Pollutant Discharge Elimination System standards. In the Third Management Plan, the director may adjust the 7 (or 15) cycles of concentration requirement for cooling towers at large-scale power plants in cases where, because of leaching from new tower components, deterioration of make-up water supplies, or other reasons, facilities are likely to experience equipment damage or come into conflict with environmental discharge regulations if they comply with the cycles of concentration requirement. Facilities must submit documentation of potential problems to support their requests to have cycles of concentration requirements reduced.

Use of effluent in cooling towers is encouraged as an alternative to groundwater use. The feasibility of this use depends on a number of factors including, among others, the availability of effluent, the volume and timing of water demand at the towers, water quality considerations, cost, any constraints on groundwater supplies, and site-specific factors such as other on-site uses for the effluent. The chemical composition of this renewable water source can vary seasonally and even daily depending on the quality, volume and source of wastewater flowing into wastewater treatment facilities. In the Third Management Plan, cooling towers at power plants are exempted from cycles of concentration requirements for the first 12 months in which effluent constitutes 50 percent or more of a tower's water supply. During this period, the power plant operator can collect data on the concentration and variability of constituents in the effluent-served cooling towers which may limit the cycles of concentration that can safely be reached and maintained. After the 12-month exemption period, the facility must either comply with the required cycles of concentration standards or propose an alternative cycles of concentration standard for effluent-served towers based on the data collected during that year.

Several additional changes have been made to the Third Management Plan to more accurately reflect facility operations. The definition of "continuous blowdown and make-up" has been revised to clarify that this term refers to continuous blowdown and make-up or frequent periodic blowdown and make-up of recirculating water. Monitoring and reporting requirements have been revised to allow total dissolved solids, other conservative mineral constituents, or electrical conductivity to be used to determine cycles of concentration. Monitoring and reporting requirements have also been revised to allow monitoring in time increments consistent with operational periods for cooling towers.

6.5.4 Large-Scale Power Plant Program

The Third Management Plan requires that power plants in operation as of the end of 1984 achieve an annual average of 7 cycles of concentration in cooling towers, while facilities that went into operation after 1984 are required to achieve an annual average of 15 cycles of concentration in their cooling towers. The cycles of concentration requirement applies only during periods when facilities are generating electricity and applies only to fully operational towers that are dissipating heat from the power generation process. In addition to achieving 7 (or 15) cycles of concentration, facilities must discharge blowdown water and add make-up water to cooling towers on a continuous basis and divert the maximum possible volume of on-site wastewater (other than blowdown water and sanitary wastewater) to the cooling process.

Facilities may be granted adjustments to their full cycles of concentration requirements in cases where, due to the quality of recirculating water, adhering to the 7 (or 15) cycles of concentration standard is likely to result in equipment damage or blowdown water exceeding environmental discharge standards. Cooling towers at power plants are exempted from cycles of concentration requirements during the first 12 months in which effluent constitutes more than 50 percent of tower water supply. After this period, facilities may request an adjustment to full cycles of concentration requirements for effluent-served towers based on the water quality of the effluent supply.

Facilities may apply to the director to use alternative conservation technologies in place of achieving 7 (or 15) cycles of concentration if the use of the proposed alternative technologies will result in equal or greater water savings. Facilities may also request a waiver from conservation requirements on the basis that cooling tower blowdown water is completely reused. Facilities must periodically measure and annually report blowdown water volumes, make-up water volumes and the chemical concentration of blowdown and make-up water. In addition, facilities must report the amount of electricity generated, the periods when they are not generating electricity, and the volume of water used for purposes other than electric power generation.

6.5.5 Non-Regulatory Efforts

Conservation assistance funds in the Tucson AMA are supporting a study of the tolerance of common landscape plants to industrial wastewater of various salinities, including blowdown water with high concentrations of total dissolved solids from an electric power plant. The goal of this study is to determine whether landscapes can successfully be irrigated with blowdown water rather than groundwater. An experimental project by Arizona Public Service in the Phoenix AMA uses cooling tower blowdown water from an electric power plant to grow halophytes (salt tolerant plants), which are being used to vegetate an urban wildlife refuge adjacent to the facility. Depending on the results of these studies, cooling tower blowdown water may be useful for replacing the use of groundwater to water existing vegetation at some locations.

6.5.6 Future Directions

In the Phoenix AMA, large-scale power plants are supplied by Type 1 and Type 2 non-irrigation grandfathered rights designated for use in electrical energy generation. Other potential water sources include CAP water and effluent, but neither of these are currently being used by the electric power industry in the AMA. The third management period requirements include a temporary exemption from the cycles of concentration standards if a facility converts to the use of at least 50 percent effluent, with the option to revise cycles of concentration requirements if needed to make long-term use of effluent viable. If this option is used during the third management period, the information gained can be used to direct research and regulatory directions in the fourth management period. Reuse of industrial wastewater in cooling towers and the use of cooling tower blowdown water for landscaping watering are water-conserving measures that should continue to be examined to determine the advantages and constraints of these conservation strategies.

6.5.7 **Industrial Conservation Requirements and Monitoring and Reporting Requirements For Large-Scale Power Plants**

6-501. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases shall have the following meanings:

1. *"Blowdown water" means water discharged from a cooling tower recirculating water stream to control the buildup of minerals or other impurities in the recirculating water.*

2. *"Conservative mineral constituent" means a component of recirculating water in a cooling tower, the concentration of which is not significantly modified by precipitation, loss to the atmosphere, or the addition of treatment chemicals.*

3. *"Continuous blowdown and make-up" means patterns in cooling tower operation that include continuous blowdown and make-up or frequent periodic blowdown and make-up of recirculating water.*

4. *"Cycles of concentration" means the ratio of the concentration of total dissolved solids, other conservative mineral constituents or electrical conductivity in the blowdown water, to the concentration of this same constituent or electrical conductivity in the make-up water.*

5. *"Effluent-served cooling tower" means a cooling tower served by a make-up water supply which, on an annual average basis, consists of 50 percent or more effluent.*

6. *"Fully operational cooling tower" means a cooling tower that is functioning to dissipate heat from a large-scale power plant that is generating electricity.*

7. *"Large-scale power plant" means an industrial facility that produces or is designed to produce more than 25 megawatts of electricity.*

8. *"Limiting constituent" means a chemical, physical, or biological constituent present in recirculating cooling tower water which, due to potential physical or biological factors, or due to potential exceedence of any federal, state, or local environmental standards upon discharge as blowdown, should not be allowed to accumulate in recirculating cooling tower water above a certain concentration.*

9. *"Make-up water" means the water added to the cooling tower recirculating water stream to replace water lost to evaporation, blowdown, or other mechanisms of water loss.*

10. *"Post-1984 power plant" means either:*

    a. *A large-scale power plant that does not qualify as a pre-1985 power plant, and includes any expanded or modified portion of the power plant if the expansion or modification includes the construction or modification of one or more cooling towers, or* *b. Any expanded or modified portion of a pre-1985 power plant if the expansion or modification includes the construction or modification of one or more cooling towers and was not substantially commenced as of December 31, 1984.*

11. "Pre-1985 power plant" means a large-scale power plant that either produced electric power as of December 31, 1984 or was substantially commenced as of December 31, 1984 and includes any expanded or modified portion of such a power plant if the expansion or modification was substantially commenced as of December 31, 1984 and included the modification or construction of one or more cooling towers.

12. "Substantially commenced as of December 31, 1984" means, with regard to the construction, expansion, or modification of a large-scale power plant, that all preconstruction permits and approvals required by federal, state, or local governments for the construction, expansion, or modification of the plant were obtained by December 31, 1984 or that a substantial capital investment in the physical on-site construction of the project was made within the 12 months prior to December 31, 1984.

6-502. Conservation Requirements for Pre-1985 Power Plants

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a pre-1985 power plant shall comply with the following requirements:

1. *An annual average of 7 or more cycles of concentration shall be achieved at fully operational cooling towers during periods when the power plant is generating electricity.*
2. *Blowdown water shall be discharged on a continuous basis, and make-up water shall be provided on a continuous basis.*
3. *The maximum amount of wastewater feasible, excluding blowdown water and sanitary wastewater, shall be diverted to the cooling process.*

6-503. Conservation Requirements for Post-1984 Power Plants

Beginning on January 1, 2002 or upon commencement of water use, whichever occurs later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a post-1984 power plant shall comply with the following requirements:

1. *An annual average of 15 or more cycles of concentration shall be achieved at fully operational cooling towers during periods when the power plant is generating electricity.*
2. *Blowdown water shall be discharged on a continuous basis, and make-up water shall be provided on a continuous basis.*
3. *The maximum amount of wastewater feasible, excluding blowdown water and sanitary wastewater, shall be diverted to the cooling process.*

6-504. Cycles of Concentration Adjustment Due to the Quality of Recirculating Water

A. *An industrial user who uses water at a large-scale power plant may apply for an adjustment to the cycles of concentration requirements set forth in section 6-502 or section 6-503,* *whichever is applicable, for any year in which compliance with the cycles of concentration requirements would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the quality of recirculating water. To apply for an adjustment to the cycles of concentration requirements based on recirculating water quality, an industrial user shall submit a request in writing to the director which includes the following information:*

1. *Historic, current, and projected water quality data for the relevant constituent(s).*

2. *Documentation describing the potential damage to cooling towers or associated equipment or documentation of environmental standards that are likely to be exceeded, whichever applies.*

B. *The director shall grant the request if the director determines that compliance with the cycles of concentration requirements set forth in section 6-502 or section 6-503, whichever is applicable, would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the quality of recirculating water.*

6-505. Exemption and Cycles of Concentration Adjustment Due to the Quality of Effluent Make-up Water Supplies

A. *The cycles of concentration requirements set forth in sections 6-502 and 6-503 do not apply to any effluent-served cooling tower at a large-scale power plant during the first 12 consecutive months in which more than 50 percent of the water supplied to the cooling tower is effluent.*

B. *After the 12-month exemption period expires, the industrial user who uses water at the large-scale power plant may apply to the director for a cycles of concentration adjustment to lower the cycles of concentration requirement for the effluent-served cooling tower if compliance with the requirement would not be possible due to the presence of a limiting constituent in the effluent supplying the tower. To apply for an alternative cycles of concentration requirement to address such a limiting constituent, an industrial user shall submit a request in writing to the director which includes the following information:*

1. *The limiting constituent that is present in the effluent supplying the tower which results in the need to blow down a greater annual volume of water than that required in section 6-502 or section 6-503, whichever is applicable.*

2. *Documentation describing the concentration at which this limiting constituent should be blown down, and the reason for the alternative blowdown level.*

The director shall grant the request if the director determines that the presence of a limiting constituent in the effluent supplying the cooling tower results in the need to blow down a greater annual volume of water than that required in section 6-502 or section 6-503, whichever is applicable. Any cycles of concentration adjustment granted pursuant to this paragraph shall apply only while the tower qualifies as an effluent-served cooling tower.

6-506. Alternative Conservation Program

An industrial user who uses water at a large-scale power plant may apply to the director to use conservation technologies other than those prescribed in section 6-502 or section 6-503, *whichever is applicable. The director shall approve the use of alternative conservation technologies if both of the following apply:*

1. *The industrial user files with the director a detailed description of the proposed alternative technologies and the water savings that can be achieved by the use of the alternative technologies.*

2. *The director determines that the alternative conservation technologies will result in water savings equal to or greater than the savings that would be achieved by the applicable conservation technologies prescribed in section 6-502 or section 6-503.*

6-507. Waiver

A. *An industrial user who uses water at a large-scale power plant may apply to the director for a waiver of any applicable conservation requirement in section 6-502 or section 6-503 by submitting a detailed long-term plan for beneficial reuse of 100 percent of the blowdown water outside the cooling circuit. Reuse of blowdown water includes the discharge of blowdown water into pipes, canals, or other means of conveyance if the discharged water is transported to another location at the plant or off the plant for reuse.*

B. *The director shall grant a waiver request if the director determines that implementation of the plan will result in the beneficial reuse of 100 percent of cooling water outside the cooling circuit. If a waiver request is granted, the industrial user shall implement the plan in accordance with the implementation schedule submitted to and approved by the director.*

6-508. Monitoring and Reporting Requirements

A. *For calendar year 2002 or the calendar year in which water use first commences, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a large-scale power plant shall include in its annual report required by A.R.S. § 45-632 the following information:*

1. *Cooling capacity (in tons) of each cooling tower at the facility.*

2. *Frequency of use and use periods of each cooling tower at the facility.*

3. *Source of water providing make-up water to each cooling tower at the facility.*

4. *For each cooling tower at the facility that is exempt from cycles of concentration requirements pursuant to section 6-505, subsection A, or for which a cycles of concentration adjustment was granted pursuant to section 6-505, subsection B, the percentage of water served to the tower during the year that was effluent.*

5. *For all fully operational cooling towers subject to cycles of concentration requirements under section 6-502 or section 6-503:*

   a. *The total quantity of blowdown water discharged from the cooling towers for each month or partial month when the facility was generating electricity during the calendar year.*

b. *The total quantity of make-up water used at cooling towers for each month or partial month when the facility was generating electricity during the calendar year.*

c. *The weighted average concentration of total dissolved solids or other conservative mineral constituent in make-up water and blowdown water at the cooling towers for each month or partial month when the facility was generating electricity during the calendar year, either:*

1) *Determined by direct analysis, or*

2) *Calculated based on average monthly electrical conductivity readings if the following conditions have been met: (a) correlations between electrical conductivity and total dissolved solids or between electrical conductivity and another conservative mineral constituent have been established over a period of one year or more in make-up and blowdown water and (b) documentation of these correlations has been provided to the director.*

6. *For each fully operational cooling tower that is exempt from cycles of concentration requirements pursuant to section 6-505, subsection A, or for which an adjusted cycles of concentration requirement was granted pursuant to section 6-504 or section 6-505, subsection B:*

a. *The total quantity of blowdown water discharged from the cooling tower for each month or partial month when the facility was generating electricity during the calendar year.*

b. *The total quantity of make-up water used at the cooling tower for each month or partial month when the facility was generating electricity during the calendar year.*

c. *The weighted average concentration of total dissolved solids or other conservative mineral constituent in make-up water and blowdown water at the cooling tower for each month or partial month when the facility was generating electricity during the calendar year, either:*

1) *Determined by direct analysis, or*

2) *Calculated based on average monthly electrical conductivity readings if the following conditions have been met: (a) correlations between electrical conductivity and total dissolved solids or between electrical conductivity and another conservative mineral constituent have been established over a period of one year or more in make-up and blowdown water and (b) documentation of these correlations has been provided to the director.*

7. *All time periods when the facility was not generating electricity.*

8. *The amount of electricity generated each month or each partial month when the facility was generating electricity during the calendar year.*

9. *The estimated quantity of water from any source, including effluent, used during the calendar year for each purpose other than electric power generation purposes.*

B. *A single annual report shall be filed for a pre-1985 power plant and a post-1984 power plant that are contiguous and owned by the same owner. The report shall describe the combined operations of the pre-1985 and post-1984 power plants as required in subsection A of this section.*

C. *All water measurements required in this section shall be made with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

6.6 LARGE-SCALE COOLING FACILITIES

6.6.1 Introduction

The purpose of cooling tower operation is to cool water that has absorbed the heat load of a heat-generating process. Cooling towers are present at a variety of commercial, industrial, and institutional facilities. Large-scale cooling facilities are defined as facilities with an aggregate cooling capacity of a minimum of 1,000 tons. The minimum cooling unit that is added to create the aggregate total of 1,000 tons is 250 tons in size. Most large-scale cooling facilities are served by municipal water providers. These facilities are termed individual users. Water providers are responsible for the Individual Users' compliance with industrial conservation requirements unless they have notified the Department of the existence of the individual user as provided in section 5-112 of the Municipal Conservation Requirements (Chapter 5), in which case the individual user is responsible for compliance. Large-scale cooling facilities served by their own wells are regulated directly by the Department and are responsible for complying with industrial conservation requirements.

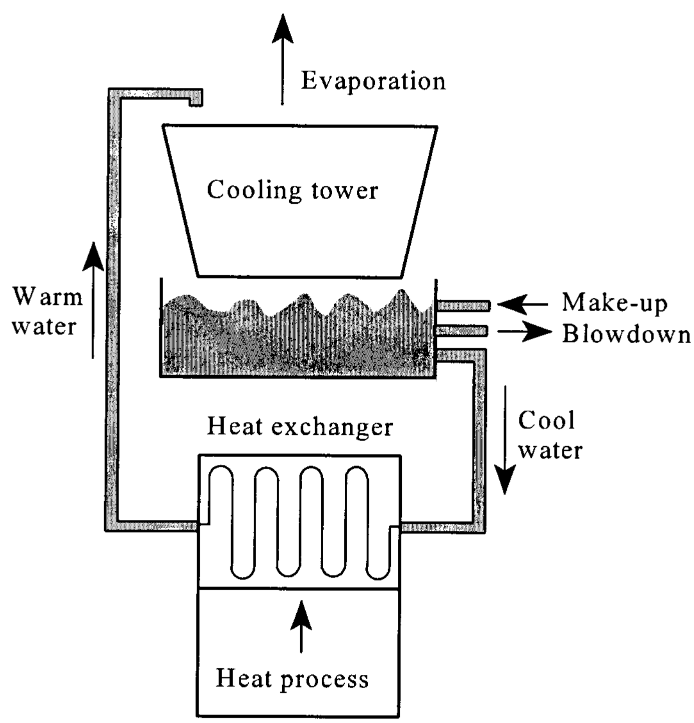
6.6.2 Water Use by Large-Scale Cooling Facilities

The main function of water in a cooling tower is to absorb heat from a heat-generating process and dissipate this heat through evaporation, as shown in Figure 6-5. Because a portion of the recirculating water is lost through evaporation, this is considered an "open" recirculating cooling loop.

The equipment served by a cooling tower varies from industry to industry; the most common is equipment used to reject heat from a large Heating, Ventilation, and Air Conditioning system (known as an HVAC system). Various equipment configurations are used to transfer heat from its source to the cooled water stream coming from the cooling tower. This transfer typically occurs inside a heat exchanger (Figure 6-5).

As a portion of cooling tower water evaporates, dissolved minerals become concentrated in the remaining water. Problems such as corrosion, mineral deposition, and biological fouling can result. These conditions reduce cooling efficiency and damage equipment. Chemical treatments including biocides, scale inhibitors, corrosion inhibitors, and addition of sulfuric acid can prolong the time mineral-laden water can safely be recirculated in towers. Mineral-laden water must be periodically discharged to prevent the excessive buildup of minerals and the possible precipitation of these minerals onto equipment surfaces. This discharge is known as "blowdown." Replacement water, known as "make-up water," is added back to the tower's recirculating water stream to replace the water lost to evaporation and blowdown.

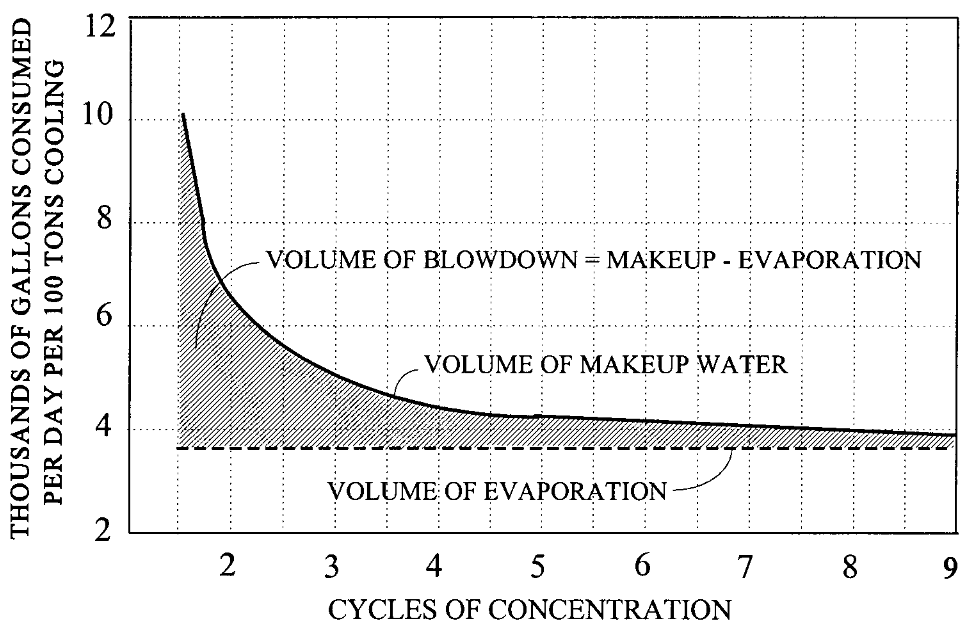
FIGURE 6-5
AN OPEN RECIRCULATING COOLING LOOP



The "cycles of concentration" or "concentration ratio" achieved in a tower indicate how efficiently water is being used in the tower. Cycles of concentration can be determined by dividing the concentration of a constituent in the blowdown water by the concentration of this same constituent in the make-up water. The concentration of total dissolved solids, a measure of the overall dissolved mineral content in water, is one commonly used constituent for calculating the cycles of concentration. For example, if the total dissolved solids concentration in blowdown water is 1,500 milligrams per liter (mg/L), and the total dissolved solids content of make-up water is 300 mg/L, the tower is operating at 5 cycles of concentration. Cycles of concentration can also be calculated using electrical conductivity measurements, water volumes, and other conservative constituents (mineral constituents whose concentrations are not altered by precipitation, loss to the atmosphere, or the addition of treatment chemicals).

Figure 6-6 illustrates the relationship between the cycles of concentration achieved in a tower and the volume of water lost through evaporation and blowdown and replaced by make-up water. At lower concentration cycles, the tower loses water through both evaporation and blowdown. At higher cycles of concentration, the rate of water consumption levels off until almost all water loss is due to evaporation. Evaporation cannot be reduced since that mechanism provides the cooling function of the tower. However, blowdown can be minimized by operating the tower at optimal efficiency. The larger the tower is, the more water will be saved as the cycles of concentration increase.

FIGURE 6-6
RELATIONSHIP BETWEEN THE CYCLES OF CONCENTRATION AND THE AMOUNT OF WATER CONSUMED BY COOLING TOWER



Cooling tower water use cannot be determined directly from water supply records because water supplies to large facilities serve a number of water needs besides cooling towers. In the absence of direct records, water use at cooling towers has been based on an estimation of the number, size, and efficiency of towers in the Phoenix AMA. Lists of large water customers served by municipal water providers in the Tucson AMA were reviewed to locate hospitals, manufacturing plants, commercial buildings, department stores, grocery stores, schools, and other facilities with large cooling demands. Questionnaires were sent to these facilities to determine tower size and water use efficiency. Based on lists of large water customers, survey results, and the size of non-residential water use in the Phoenix AMA relative to the Tucson AMA, it is estimated there are about 3,000 towers of all sizes in the Phoenix AMA.

The size or cooling capacity of a tower is often described in units of tons. Cooling capacity tonnage indicates the rate at which the cooling tower can reject heat. Cooling tower capacities can range from as little as 50 tons to over 1,000 tons. Large industrial or commercial facilities may have several large towers. As discussed in the next section, third management period conservation requirements apply to facilities with a total cooling capacity of 1,000 tons or more. Based on the survey results, approximately 100 facilities may fit into this regulatory category. Assuming towers at these facilities average 1,000 tons in capacity and operate 24 hours a day at 3 cycles of concentration, they would use approximately 22,800 acre-feet of water annually. These estimates need to be confirmed with additional field data.

Future water use by regulated cooling towers will depend on the size and number of newly constructed facilities and the cycles of concentration achieved at all regulated towers. Assuming cooling tower construction parallels population growth, the number of towers in the Phoenix AMA could nearly double by 2025. At three cycles of concentration, facilities subject to third management period conservation requirements could use 42,600 acre-feet per year by 2025.

6.6.3 Program Development and Issues

There were no conservation requirements in the First Management Plan for cooling towers other than for towers serving the electric power industry (section 6.5 of this chapter). Beginning in the Second Management Plan, regulations went into effect for "new large cooling users," defined as facilities with an aggregate tower capacity in excess of 250 tons which went into operation after January 1, 1990. Cooling towers at facilities in this category were required to achieve a concentration of 2,000 mg/l of total dissolved solids in recirculating water before blowing it down. The cutoff date of January 1, 1990 was intended to focus on new facilities with cooling towers, which could be identified as they established hook-ups with water providers. This identification process has proved to be difficult, and a complete list of facilities subject to Second Management Plan requirements has not been developed.

The Third Management Plan includes several changes intended to increase the effectiveness of conservation requirements for cooling towers. The facilities subject to regulation have been expanded from "new" facilities to facilities of all ages, because cooling technology has not changed significantly over time, and age alone does not preclude towers at facilities from achieving water use efficiency. At the same time, the size of regulated facilities has been shifted upwards to include only those facilities with an aggregate cooling capacity of 1,000 tons or more. In determining the aggregate cooling capacity of a facility, only cooling towers that are 250 tons or more in size are considered, and only towers of this size or larger have specific blowdown requirements. This size cutoff excludes small capacity towers at which it may not be cost effective to conduct monitoring and install chemical feed equipment. Eliminating the January 1, 1990 cutoff date increases the number of facilities subject to regulation and increases the potential water savings. Identifying facilities subject to Third Management Plan requirements should be facilitated by concentrating on larger scale industries, commercial buildings, and institutions which need 1,000 tons or more of cooling capacity.

In the Second Management Plan, facilities were required to achieve a recirculating water concentration of 2,000 mg/l of total dissolved solids in cooling towers before blowing down. Blowdown standards in the Third Management Plan have been shifted from total dissolved solids to silica- and hardness-based standards. While the concentration of total dissolved solids is relatively easy to estimate using electrical conductivity as a surrogate and the 2,000 mg/l cutoff level addresses to some extent the water quality variations in make-up water supplies, silica and total hardness are more useful as indicators of the maximum concentration cycles that can safely be achieved in a tower. Silica can build up in recirculating water and damage equipment by precipitating a layer of "glass" inside piping. This silica layer reduces heat transfer and requires expensive repairs. The total hardness of water is a measure of the presence of calcium and magnesium salts, which can precipitate to form scale inside cooling towers and associated piping.

The purpose of Third Management Plan regulations is to effectively move large-scale cooling facilities toward more water-conserving management practices while operating within a range that safely avoids mineral precipitation in cooling towers and associated piping. As required in the Code, conservation requirements for industrial users must be based on the use of the latest commercially available conservation technology consistent with reasonable economic return. Conservation requirements in the Third Management Plan focus on standards that can be achieved using conventional chemical treatment to extend cycles of concentration in cooling towers. This is the most efficient proven conservation technology currently available without major capital outlays. Several new commercially available technologies for tower operation and maintenance are available but have drawbacks because they are unproven technologies, they have high initial capital costs, or they do not work efficiently at high desert temperatures.

In the Third Management Plan, large-scale cooling facilities must achieve concentrations of either 120 mg/l of silica or 1,200 mg/l of total hardness, whichever is reached first, before blowing down the recirculating water from towers with 250 tons or more of cooling capacity. The solubility limit of silica in water is around 150 mg/l. Allowing facilities to discharge water when silica reaches 120 mg/l provides a margin of safety against costly equipment damage. The solubility limit of total hardness is a function of the chemical treatment used in a tower. Large cooling towers can generally operate safely at concentrations of around 1,200 mg/l total hardness in the recirculating water so this was selected as the Third Management Plan total hardness standard. Total hardness is typically expressed as an equivalent concentration of calcium carbonate ("hardness as calcium carbonate"), though both calcium and magnesium salts are included in this expression.

Third Management Plan cooling tower blowdown requirements apply only when towers are functioning to dissipate heat. Some towers are operated periodically based on seasonal or workload patterns, rather than being operated continuously. During periods when they are not dissipating heat, water may still need to be recirculated through towers to keep surfaces wetted, but evaporation fans may be turned off to reduce electricity use. This reduces the normal rate of evaporation. When the recirculating water becomes stagnant, it needs to be blown down whether or not blowdown standards have been met.

Use of effluent in cooling towers is encouraged as an alternative to groundwater use. The feasibility of this use depends on a number of factors including the availability of effluent, the volume and timing of water demand at the towers, water quality considerations, cost, any constraints on groundwater supplies, and site-specific factors such as other on-site uses for the effluent. The chemical composition of this renewable water source can vary seasonally and even daily depending on the quality, volume, and source of wastewater flowing into wastewater treatment facilities. For the third management period, a cooling tower at a large-scale cooling facility is exempt from cooling tower blowdown requirements for the first 12 months in which effluent constitutes 50 percent or more of the water supply to that tower. During this period, the facility operator will collect data on the concentration and variability of constituents in make-up water that may limit the cycles of concentration that can safely be reached and maintained. After the 12-month exemption period, the facility must either comply with the silica/total hardness blowdown standards for the tower or propose an alternative blowdown standard based on the data collected during that year.

For all facilities subject to Third Management Plan requirements, in cases where the build up of constituents other than silica or total hardness in cooling tower recirculating water is likely to result in damage to cooling towers or is likely to result in exceeding environmental discharge standards, facilities may apply to use an alternative blowdown standard.

6.6.4 Large-Scale Cooling Facility Program

Large-scale cooling facilities are facilities with a total cooling capacity of 1,000 tons or more. The following Third Management Plan conservation requirements apply to cooling towers that are located at large-scale cooling facilities and that have 250 tons or more of cooling capacity.

- Fully operational cooling towers with 250 tons or more of cooling capacity must achieve either 120 mg/l of silica or 1,200 mg/l of total hardness in recirculating water, whichever is reached first, before blowing down.
- If needed, a facility may apply for an alternative blowdown standard for any tower using effluent. During the initial 12-month period during which 50 percent or more of the water used by a tower is effluent, the tower is exempt from blowdown standards.
- If needed, a facility may apply for an alternative blowdown standard for any tower if compliance with blowdown requirements would likely result in damage or exceedence of environmental discharge standards because of the accumulation of a limiting constituent other than silica or total hardness.
- Facilities must record monthly and report annually the volumes of tower make-up water and blowdown water and the concentrations of silica, total hardness, or approved alternative constituent, in both make-up water and blowdown water.

6.6.5 Non-Regulatory Efforts

The Phoenix AMA has partially funded industrial, commercial, and institutional water conservation workshops sponsored by the Arizona Municipal Water Users Association. The workshops provided classroom instruction, site visits, and mentoring of individual water auditing efforts by participants as part of a water audit certification program. Cooling towers were among the several uses audited.

To encourage water conservation in facilities of all sizes, a cooling tower training video has been prepared which describes how water can be conserved by improving the efficiency of tower maintenance. The video and an accompanying workbook were prepared through a Tucson AMA conservation assistance grant.

6.6.6 Future Directions

Identification of the regulated community is a high priority for the cooling tower program during the third management period. During this period, data on the number, size, and efficiency of cooling towers will be collected. Based on the collected data, the effectiveness of these programs will be determined. Fourth management period requirements will be adjusted accordingly. New cooling tower maintenance technologies will continue to be investigated and can be incorporated into future conservation requirements.

Experiences gained by facilities converting to effluent use in the third management period can be used to direct research and regulatory directions in the fourth management period. Reuse of industrial wastewater in cooling towers and the use of cooling tower blowdown water for landscape watering should continue to be examined to determine the advantages and constraints of these recycling approaches.

6.6.7 <u>Industrial Conservation Requirements and Monitoring and Reporting Requirements for Large-Scale Cooling Facilities</u>

6-601. Definitions

In addition to the definitions set forth in Cchapters 1 and 2 of Title 45 of the Arizona Revised Statutes , unless the context otherwise requires, the following words and phrases shall have the following meanings:

1. *"Blowdown water" means water discharged from a cooling tower recirculating water stream to control the buildup of minerals or other impurities in the recirculating water.*

2. *"Conservative mineral constituent" means a component of recirculating water in a cooling tower, the concentration of which is not significantly modified by the addition of treatment chemicals.*

3. *"Cycles of concentration" means the ratio of the concentration of a conservative mineral constituent or electrical conductivity in the blowdown water to the concentration of this same constituent or electrical conductivity in the make-up water.*

4. *"Effluent-served cooling tower" means a cooling tower served by a make-up water supply which on an annual average basis consists of 50 percent or more effluent.*

5. *"Fully operational cooling tower" means a cooling tower that is functioning to dissipate heat.*

6. *"Large-scale cooling facility" means a facility which has control over cooling operations with a total combined cooling capacity greater than or equal to 1,000 tons. For the purposes of this definition, the minimum cooling tower size which shall be used to determine total facility cooling capacity is 250 tons. A large-scale cooling facility does not include a large-scale power plant that utilizes cooling towers to dissipate heat.*

7. *"Large-scale power plant" means an industrial facility that produces or is designed to produce more than 25 megawatts of electricity.*

8. *"Limiting constituent" means a chemical, physical, or biological constituent present in recirculating cooling tower water which, due to potential physical or biological factors or due to potential exceedence of any federal, state, or local environmental standards upon discharge as blowdown, should not be allowed to accumulate in recirculating cooling tower water above a certain concentration.*

9. *"Make-up water" means the water added back into the cooling tower recirculating water stream to replace water lost to evaporation, blowdown, or other mechanisms of water loss.*

6-602. Conservation Requirements

A. Conservation Requirements

Beginning on January 1, 2002 or upon commencement of water use, whichever occurs later, and continuing thereafter until the first compliance date for any substitute conservation *requirement in the Fourth Management Plan, an industrial user who uses water at a large-scale cooling facility shall comply with the following requirements:*

Each fully operational cooling tower with greater than or equal to 250 tons of cooling capacity at the facility shall achieve a cycles of concentration level that results in blowdown water being discharged at an average annual minimum of either 120 mg/l silica or 1,200 mg/l total hardness, whichever is reached first.

B. Exemptions and Alternative Blowdown Standards

1. *The requirement set forth in subsection A of this section does not apply to a large-scale cooling facility in any year in which 100 percent of facility blowdown water is beneficially reused.*

2. *The requirement set forth in subsection A of this section does not apply to any effluent-served cooling tower at a large-scale cooling facility during the first 12 consecutive months in which more than 50 percent of the water supplied to the cooling tower is effluent. After the 12-month period expires, the person using water at the effluent-served cooling tower may apply to the director to use an alternative blowdown level from that required in subsection A of this section if compliance with the blowdown requirement would not be possible due to the presence of a limiting constituent other than silica or total hardness in the effluent supplying the tower. To apply for an alternative blowdown level to address such a limiting constituent, an industrial user shall submit a request in writing to the director which includes the following information:*

    a. *The limiting constituent other than silica or total hardness that is present in the effluent supplying the tower which results in the need to blow down a greater annual volume of water than that required under subsection A of this section.*

    b. *Documentation describing the concentration at which this limiting constituent should be blown down and the reason for the alternative blowdown level.*

    The director shall grant the request if the director determines that the presence of a limiting constituent other than silica or total hardness in the effluent supplying the cooling tower results in the need to blow down a greater annual volume of water than that required under subsection A of this section. Any alternative blowdown level granted pursuant to this paragraph shall apply only while the tower qualifies as an effluent-served cooling tower.

3. *An industrial user may apply to the director to use an alternative blowdown level from that required in subsection A of this section if compliance with the blowdown requirement would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the accumulation of a limiting constituent other than silica or total hardness in recirculating water. To apply for an alternative blowdown level for such a limiting constituent, an industrial user shall submit a request in writing to the director which includes the following information:*

    a. *Historic, current, and projected water quality data for the relevant limiting constituent(s).*

b. Documentation describing the potential damage to cooling towers or associated equipment, or documentation of environmental standards that are likely to be exceeded, whichever applies.

The director shall grant the request if the director determines that compliance with the blowdown level set forth in subsection A of this section would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the accumulation of a limiting constituent other than silica or total hardness in recirculating water.

6-603. Monitoring and Reporting Requirements

For calendar year 2002 or the calendar year in which water use first commences, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user who uses water at a large-scale cooling facility shall include in its annual report required by A.R.S. § 45-632 the following information for all cooling towers with 250 tons or more of cooling capacity at the facility:

1. *Capacity in tons of each cooling tower.*

2. *Number of days per month that each cooling tower was fully operational.*

3. *For each cooling tower that is exempt from cycles of concentration requirements or for which an alternative blowdown level has been granted, pursuant to section 6-602, subsection B, paragraph 2, the percentage of water served to the tower during the year that was effluent.*

4. *The quantity of water from any source, specified by source, which was used for make-up water on a monthly basis during the calendar year as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

5. *The quantity of water which was blown down on a monthly basis during the calendar year as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

6. *The average monthly concentrations of silica, total hardness, or other approved limiting constituent established under section 6-602, subsection B, paragraph 2 or 3, in make-up and blowdown water for those portions of each month when cooling towers were fully operational during the calendar year, reported in mg/l or other measurement units established under section 6-602, subsection B, paragraph 2 or 3, and either:*

   a. *Determined by direct analysis; or*

   b. *Calculated based on average monthly electrical conductivity readings for those portions of each month when cooling towers were fully operational if the following conditions have been met: (a) correlations between electrical conductivity and silica, between electrical conductivity and total hardness, or between electrical conductivity and another approved limiting constituent established pursuant to section 6-702 subsection B, paragraph 2 or 3, have been established over a period of one year or more in make-up and blowdown water; and (b) documentation of these correlations has been provided to the director.*

6.7 DAIRY OPERATIONS

6.7.1 Introduction

The Department regulates dairy operations that annually house a monthly average of 100 or more lactating cows per day. The majority of water use at dairy operations occurs for animal drinking needs, udder washing, barn cleanup, and animal cooling.

6.7.2 Water Use by Dairy Operations

There are 86 dairy operations in the Phoenix AMA, which are clustered southeast of Chandler, Gilbert, and Mesa, and in the West Valley. Dairy operations in the AMA hold Type 1 and Type 2 non-irrigation grandfathered rights and groundwater withdrawal permits that have a combined annual allotment of nearly 15,700 acre-feet. Water use in 1995 was over 8,400 acre-feet. Water use by dairy operations has been steadily increasing since 1989 and it is projected this trend will continue through the year 2025. However, many variables may affect this projection. As urban development in the Phoenix metropolitan area expands further outward, many dairy operations have chosen to relocate away from new residential development, in some cases opting for a more rural environment such as that found in the Pinal AMA. Other dairies, however, prefer to stay closer to processing facilities located in the AMA.

Figure 6-7 shows how water is used at a dairy. A significant amount of water is used for the milking cycle. The first step in the milking cycle at most dairy operations is moving the cows into a holding pen, where the udders are washed before milking. Sprinklers, arranged in a grid pattern on the floor of the pen, are turned on to wash the udders. The cows may be cooled during udder washing to enhance milk production. The animals are then moved to the milking parlor for milking, after which they are returned to the corral area through return lanes. Each time the cycle is completed, the holding pen and parlor areas are cleaned, milk lines are washed, milking equipment is cleaned and sanitized, and manure is removed.

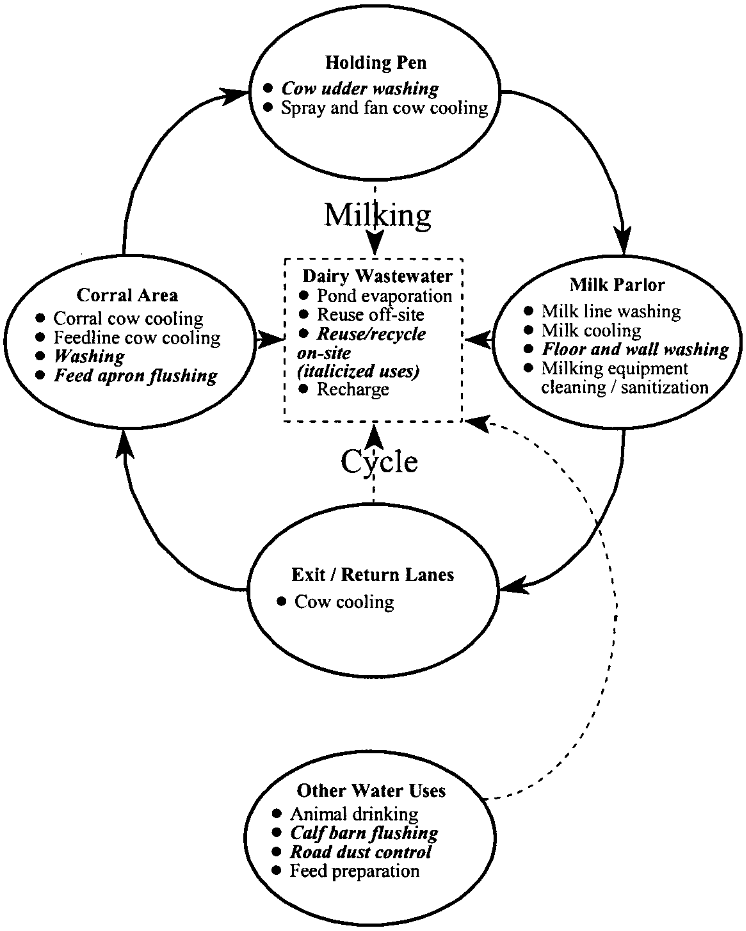
A number of dairy management decisions affect water use. Animal cooling to reduce heat stress and enhance milk production is an increasingly common management practice. Cooling is usually done when temperatures exceed 85 to 90 degrees Fahrenheit and may be done at a number of points in the milking cycle, including the holding pen corral, at the parlor exit, along the fenceline feeding area, or in the corral area. Approximately 95 percent of dairy operations in the AMAs cool their cows during some portion of the milking cycle. Cooling practices have increased during the past decade and are expected to continue to increase in the future. Whereas at many existing dairy operations lactating cows are often cooled at only one or two of the possible locations, newly designed dairy operations incorporate cooling wherever possible.

Milking cycle frequency is another management decision that affects water use. Cows may be milked two, three, or even four times daily. Increasing the number of milking cycles per day will increase water use. Dairy managers evaluate the benefits of milking two or three times per day based upon parlor capacity, milk yield, staffing, and other economic factors. If future market demand requires increasing milk pounds of production per cow, milking three or four times a day could become commonplace.

Aside from the milking cycle, water is used for drinking needs, dust control, and, at some dairy operations, feed preparation. Water used for drinking needs varies depending upon whether the animal present at the facility is a lactating cow (a cow producing milk) or a non-lactating animal (calves, heifers, dry cows, bulls, and steers). A lactating cow drinks an average of 30 gallons of water per day and a non-lactating animal drinks an average of 15 gallons per day, with some seasonal variation.

Whether replacement animals and non-lactating animals are housed on or off-site can significantly affect water use. Each dairy keeps lactating and mature dry cows on-site at a ratio that remains relatively constant throughout the year, with some variation due to weather and breeding. Another management decision is whether replacement animals, such as calves and heifers, are housed on-site. Typically, if replacement animals are housed on-site, the total number of replacement animals plus mature dry cows equals the number of lactating cows. Some dairy managers prefer to purchase replacement animals as needed or raise the animals in cooler climates until they near calving age. Approximately 33 percent of Arizona dairy operations raise their replacement animals off-site.

FIGURE 6-7
WATER USE AT A TYPICAL DAIRY OPERATION



Italicized items can use reused and/or recycled water
Not all water uses shown on this chart exist at every dairy

Within the milking cycle, the dairy industry practices that have the most significant water conservation potential are the udder washing process, the practice of water recycling, and, to a lesser extent, cleaning and sanitization. The typical udder washing cycle consists of a one minute washing, a two minute break, followed by a three minute washing. At many dairy operations, more water is used in the udder washing process during the summer months, though no increase is warranted for sanitation reasons. Summer water use can be reduced with little or no additional management or equipment costs. Many dairy operations have invested in automatic timers to manage the udder wash system. Timers reduce the potential for excessive manual washing, provided the timer is used appropriately. Proper management is the best way to control water use, and the use of automatic timers can result in significant water savings. Other factors affect the amount of water used for udder washing. Regular and frequent washing of the corral walkway areas reduces the potential for soiled udders and thus reduces wash water needs. Periods of wet weather result in muddy corrals, requiring longer udder washing cycles or increased washing of corral walkways and milking areas.

Another important water conservation practice for dairy operations is recycling of wastewater generated by the dairy. Wastewater may be conveyed to a lagoon where it evaporates, delivered off-site for non-dairy uses (such as irrigating crops), or recycled and reused at the dairy. Many opportunities for recycling exist at a dairy. Milk cooling using vacuum pumps produces discharged water that can be captured and used in the udder washing cycle or for certain other washing and cleaning purposes. At some facilities, depending on how the recycled water is used initially, this water can be captured a second time and used again. For example, recycled water used for udder washing may be recycled again to wash corral walkways. Recycling offers the dairy manager several benefits, including lower water costs, less wastewater to dispose of, less freestanding water, drier conditions, and cleaner cows. Recycling should be evaluated and implemented wherever feasible in new dairy operations. However, health and sanitary requirements may prohibit the use of recycled water for certain water uses at a dairy.

At many dairy operations, the amount of water used for cleaning and sanitizing the holding pen, milking parlor, and milk transport lines after each milking increases during the summer months, though no increase may be warranted. Summer water use for this purpose can easily be reduced with little or no additional management or equipment costs.

6.7.3 Program Development and Issues

During the first management period, dairy operations did not have any specific conservation requirements. When the Second Management Plan was developed, the Department conducted a study to identify dairy water use patterns, processes, and associated water use to determine conservation potential for dairy operations. Several dairy operations were visited during the study. Experts from the University of Arizona reviewed and supplemented the study and had significant input on the conservation requirements. Conservation requirements for the second management period established a maximum annual water allotment for dairy operations effective in the year 2000. The maximum annual water allotment was determined using per animal water use needs for lactating cows and non-lactating animals, and could vary depending on the number of animals at the facility. Upon application, the Department could approve an additional allocation of water for a dairy operation above its annual allotment if the dairy operation demonstrated that milking, sanitary, or cooling needs would require more water.

During the second management period, rapid changes in cooling technologies and the increased diversity in dairy size and design made it difficult for some dairy operations to conform to an allotment-based conservation requirement like that included in the Second Management Plan. In an effort to have higher milk production efficiency, newer dairy operations tend to employ more cooling practices and incorporate more methods to recycle or reuse water.

The Department was informed by the Dairy TAC that future dairy facilities will have to be larger and utilize these new cooling technologies in order to be economically competitive. These practices are designed to increase the milk yield per lactating cow, and will require more water than historical use indicates. The conservation program for the third management period provides dairy operations the opportunity to choose one of two conservation programs. Dairy operations may continue to be regulated under an allotment-based program identical to Second Management Plan requirements or may apply for requirements that are specified as "best management practices."

6.7.4 Dairy Operation Conservation Program

6.7.4.1 Allotment-Based Requirements

The amount of water required by a dairy depends on the number of cows and non-lactating animals housed at the dairy, the breed of cow, the dairy management practices, and the type and water use efficiency of the technology employed. Table 6-5 summarizes daily water needs for each dairy process, assuming the use of appropriate water conservation technologies and practices. The water needs listed are based on two assumptions: (1) milking is done three times per day per lactating animal and (2) cooling is done during the milking cycle for at least a portion of the herd.

The assumptions of Table 6-5 are the basis for the annual water allotment for dairy operations. When calculating the total annual allotment, lactating cows are allotted 105 gallons per animal per day (GAD) while non-lactating animals are allotted 20 GAD. The allotment is calculated annually and will vary with the monthly average of lactating cows and non-lactating animals per day present at the dairy each year.

TABLE 6-5
WATER NEEDS AT A TYPICAL DAIRY

Operation	Water Use Allocation (Gallons per Day)	
	Lactating Cow	Non-lactating Animal
Drinking needs[1]	30	15
Udder washing - based on 72 minutes/day at 8 gallons/minute; 16 cows per spray head. Varies with number of milkings per day.[1]	35	0
Barn clean-up and sanitizing. Varies with number of milkings per day.[1]	20	0
Animal cooling management option, site-specific	10	0
Calf barn cleanup	0	5
Milk cooling tower (if present)	5	0
Miscellaneous	5	0
TOTAL	**105**	**20**

[1] Assumes three milkings per day

Upon application, the Department may approve an additional allocation of water for a dairy operation above its annual allotment if the dairy operation demonstrates that one or more of the following conditions exist:

- Milking is being done more than three times daily;
- Technologies that are designed to achieve industry health and sanitation objectives, such as the recommended pre-milking sanitation method, are being used; or
- Animal cooling technologies designed to increase milk production are being used that require more than 10 gallons per lactating cow per day.

In consideration of weather variability, the Department has included a three-year averaging provision in the maximum annual water allotments in the third management period. The water use of three consecutive years can be averaged to determine if compliance with the Third Management Plan allotment has been achieved.

6.7.4.2 Best Management Practices Requirements

As an alternative to the annual allotment requirement, a dairy may submit an application to the director to be regulated under the Best Management Practices Program. This program requires that a combination of best management practices (BMPs) be implemented, which include effective management and the installation of specific conservation technologies in the following water use categories:

- Delivery of drinking water for dairy animals;
- Udder washing and milk parlor cleaning;
- Corral design and maintenance;

- Cleaning and sanitization of milking equipment;
- Dust control, calf housing cleaning, and feed apron flushing;
- Dairy animal cooling; and
- Dairy animal feed preparation.

Implementation of all the standard BMPs listed in Appendix 6C will have a specific measurable result. While most of the standard BMPs are applicable to all dairies, the water use activities associated with some of the standard BMPs may not exist at all dairies. If a dairy cannot implement a standard BMP, the dairy may apply to implement a substitute BMP with a specific measurable result that demonstrates a water savings equivalent to the water savings associated with the standard BMP. If a substitute BMP is not possible, the dairy may apply for a waiver of the standard BMP. The director may grant a waiver only for the following standard BMPs: (1) BMP 2.1.2 (Udder Wash System); (2) BMP 2.2.2 (Milking Parlor Floor and Wall Washing); (3) BMP 4.1.1 (Milk Cooling and Vacuum Pump); (4) all of the standard BMPs in Water Use Category No. 5 (Dust Control, Calf Housing Cleaning and Feed Apron Flushing); (5) all of the standard BMPs in Water Use Category No. 6 (Dairy Animal Cooling); and (6) all of the standard BMPs in Water Use Category No. 7 (Dairy Animal Feed Preparation).

Five years after a dairy is accepted for regulation under the Best Management Practices Program (BMP Program), the director will review the dairy's BMPs to determine if they are still appropriate. If the BMPs are no longer appropriate due to an expansion of the dairy or a change in management practices, the director will require a modification to the BMPs.

6.7.5 Non-Regulatory Efforts

Dairy operations stand to benefit from a conservation assistance grant that is supporting the construction and study of an on-site demonstration of dairy wastewater treatment through constructed wetlands. Wastewater from cow barns (from cow washing, etc.) is collected and solids are removed. The wastewater is then cycled through a series of wetland cells. The quality of water obtained from this process is closely monitored. This treatment facility will attempt to assess the ability of constructed wetlands to produce water suitable for reuse in the dairy or for recharge.

Research is needed to further investigate the quantity of water required for various processes at a dairy operation. This should include the water use of new technologies designed to increase milk production.

6.7.6 Future Directions

Although newer dairy operations tend to use more water for cow cooling than older dairy operations by employing more cooling technologies and practices, thoughtful design will allow dairy operations to reuse and recycle more water than they have in the past. The latest "state of the art" dairy operations even collect and use rainfall. Fourth management period conservation requirements may need to be adjusted with the increased utilization of more water-intensive technologies. Any adjustment to current allotments must be based on more reliable data from a verifiable study. Alterations to allotments or to BMPs must be based on additional research that either quantifies the water requirements associated with these new technologies or provides new information on existing technologies.

6.7.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Dairy Operations

6-701. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-702 through 6-705 of this chapter shall have the following meanings:

1. *"Dairy animal" means a lactating cow or a non-lactating animal present at a dairy operation.*

2. *"Dairy operation" means a facility that houses a monthly average of 100 or more lactating cows per day during a calendar year as calculated in 6-702 .*

3. *"Dairy wastewater" means any water that has been put to a beneficial use at the dairy operation, including water containing dairy animal wastes.*

4. *"Lactating cow" means any cow that is producing milk that is present on-site at a dairy operation and receives water through the dairy operation's watering system.*

5. *"Non-lactating animal" means a calf, heifer, mature dry cow, bull, or steer that is present on-site at a dairy operation and receives water through the dairy operation's watering system.*

6-702. Maximum Annual Water Allotment Conservation Requirements

A. Maximum Annual Water Allotment

Beginning on January 1, 2002 or upon commencement of water use, whichever is later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user shall not withdraw, divert, or receive water for use at a dairy operation during a calendar year in a total amount that exceeds the dairy operation's maximum annual water allotment for the year as calculated in subsection B below, unless the industrial user applies for and is accepted into the Best Management Practices Program described in section 6-704 below.

B. Calculation of Maximum Annual Water Allotment

A dairy operation's maximum annual water allotment for a calendar year shall be as follows:

1. *Calculate the average daily number of lactating cows and non-lactating animals that are present during the calendar year. The average daily number of lactating cows and non-lactating animals present during the calendar year shall be calculated as follows:*

   a. *On the last day of each month, determine the total number of lactating cows and non-lactating animals present at the dairy operation.*

   b. *For each category of animal, add together the total number of such animals present at the dairy operation on the last day of each month during the year in question and then divide the result by 12. The quotient is the average daily number of lactating cows and non-lactating animals present during the calendar year.*

2. *Calculate the dairy operation's maximum annual water allotment for the calendar year as follows:*

   a. *Multiply the average daily number of lactating cows present during the calendar year by 105 gallons per animal per day (GAD) and then convert to acre-feet per year as follows:*

$$C_L \times \frac{105\ GAD}{325{,}851\ g/af} \times d/yr = \text{Maximum annual water allotment for lactating cows (acre-feet per year)}$$

Where: C_L = *Average daily number of lactating cows*

GAD = *Gallons per animal per day*
g/af = *Gallons per acre-foot*
d/yr = *Days in the year*

The result is the dairy operation's maximum annual water allotment for lactating cows for the calendar year.

   b. *Multiply the average daily number of non-lactating animals present during the calendar year by 20 gallons per animal per day (GAD) and then convert to acre-feet per year as follows:*

$$A_N \times \frac{20\ GAD}{325{,}851\ g/af} \times d/yr = \text{Maximum annual water allotment for non-lactating animals (acre-feet per year)}$$

Where: A_N = *Average daily number of non-lactating animals*
GAD = *Gallons per animal per day*
g/af = *Gallons per acre-foot*
d/yr = *Days per year*

The result is the dairy operation's maximum annual water allotment for non-lactating animals for the calendar year.

   c. *Add the dairy operation's maximum annual water allotment for non-lactating animals for the calendar year as calculated in subparagraph b of this paragraph and the dairy operation's maximum annual water allotment for lactating cows for the calendar year as calculated in subparagraph a of this paragraph. The sum is the maximum annual water allotment for the dairy operation for the calendar year, except as provided in subparagraph d of this paragraph.*

   d. *Upon application, the director may approve an additional allocation of water for the dairy operation consistent with industry health and sanitation objectives if the dairy operation requires more than its maximum annual water allotment because of one or more of the following:*

      1) *Milkings per lactating cow occur more than three times daily;*

      2) *Technologies are used to achieve industry health and sanitation objectives that require additional water use; and*

3) Technologies are designed and/or implemented for cooling lactating cows and non-lactating animals, which increase milk production.

3. Nothing in this section shall be construed to authorize a person to use more water from any source than the person is entitled to use pursuant to a groundwater or appropriable water right or permit held by the person. Nor shall this section be construed to authorize a person to use water from any source in a manner that violates Chapter 1 or Chapter 2 of Title 45, Arizona Revised Statutes.

6-703. Compliance with Maximum Annual Water Allotment

An industrial user who uses water at a dairy operation is in compliance for a calendar year with the dairy operation's maximum annual water allotment if the director determines that either of the following applies:

1. *The volume of water withdrawn, diverted, or received during the calendar year for use at the dairy operation, less the volume of dairy wastewater delivered from the dairy operation to the holder of a grandfathered groundwater right for a beneficial use, is equal to or less than the dairy operation's maximum annual water allotment for the calendar year; or*

2. *The three-year average volume of water withdrawn, diverted, or received for use at the dairy operation during that calendar year and the preceding two calendar years is equal to or less than the dairy operation's three-year average maximum annual water allotment for that calendar year and the preceding two calendar years. In calculating the three-year average volume of water withdrawn, diverted, or received for use at the dairy operation, the volume of dairy wastewater delivered from the dairy operation to the holder of a grandfathered right for a beneficial use shall not be counted.*

6-704. Best Management Practices Program Conservation Requirements

A. Criteria for Approval of Application

An industrial user who uses water at a dairy operation may apply for regulation under the Best Management Practices Program (BMP Program) by submitting an application on a form provided by the director. The director shall approve a complete and correct application for regulation under the BMP Program if the director determines that the applicant will implement all of the standard best management practices (BMPs) described in Appendix 6C, unless the director approves a substitution of a standard BMP under subsection D of this section or a waiver of a standard BMP under subsection E of this section. If the director approves a substitution of a standard BMP, the director shall approve the application if the director determines that the applicant will implement the substitute BMP or BMPs in addition to any remaining standard BMPs.

B. Exemption from Maximum Annual Water Allotment Conservation Requirements

An industrial user accepted for regulation under the BMP Program is exempt from the maximum annual water allotment conservation requirements set forth in section 6-702 beginning on January 1 of the first calendar year after the industrial user's application for the BMP Program is approved, unless the director approves an earlier date.

C. Compliance with Best Management Practice Program

Beginning on a date established by the director and continuing thereafter until the first compliance date for any substitute conservation requirement established in the Fourth Management Plan, an industrial user accepted for regulation under the BMP Program shall comply with all standard BMPs listed in Appendix 6C, unless the director approves a substitution of a standard BMP under subsection D of this section, or a waiver of a standard BMP, under subsection E of this section. If the director approves a substitution of a standard BMP, the industrial user shall comply with the substitute BMP or BMPs in addition to any remaining standard BMPs. The standard BMPs listed in Appendix 6C are broken into the following seven categories: (1) delivery of drinking water for dairy animals; (2) udder washing and milking parlor cleaning; (3) corral design and maintenance; (4) cleaning and sanitizing milking equipment; (5) dust control, calf housing cleaning, and feed apron flushing; (6) dairy animal cooling; and (7) dairy animal feed preparation.

D. Substitution of Best Management Practices

1. *The director may allow an industrial user applying for the BMP Program to replace a standard BMP listed in Appendix 6C with a substitute BMP if the director determines that the standard BMP cannot be achieved and that implementation of the substitute BMP will result in water use efficiency equivalent to that of the standard BMP. To apply for a substitution of a standard BMP, the industrial user shall include in its application for the BMP Program an explanation of why the standard BMP is not achievable and a description of how the substitute BMP will result in water use efficiency equivalent to that of the standard BMP.*

2. *An industrial user regulated under the BMP Program may apply to the director for a substitution of an existing BMP that is no longer appropriate for the industrial user's dairy operation. The director may allow the industrial user to replace the existing BMP with a substitute BMP if the director determines that the substitute BMP will result in water use efficiency equivalent to that of the existing BMP.*

E. Waiver of Best Management Practices

1 *The director may waive a standard BMP listed in paragraph 3 of this subsection if the director determines that the standard BMP cannot be achieved and that no substitute BMP is appropriate. To apply for a waiver of a standard BMP listed in paragraph 3, the industrial user shall include in its application for the BMP Program an explanation of why the standard BMP is not achievable and why no substitute BMP is appropriate.*

2. *An industrial user regulated under the BMP Program may apply to the director for a waiver of an existing BMP listed in paragraph 3 of this subsection if the BMP is no longer appropriate for the industrial user's dairy operation. The director may waive the BMP if the director determines that the existing BMP is longer appropriate for the industrial user's dairy operation and that no substitute BMP is appropriate.*

3. *Only the following standard BMPs may be waived by the director under this subsection: (1) BMP 2.1.2 (Udder Wash System); (2) BMP 2.2.2 (Milking Parlor Floor and Wall Washing); (3) BMP 4.1.1 (Milk Cooling and Vacuum Pump); (4) all of the standard BMPs in Water Use Category No. 5 (Dust Control, Calf Housing Cleaning, and Feed Apron Flushing); (5) all of the standard BMPs in Water Use Category No. 6 (Dairy*

Animal Cooling); and (6) all of the standard BMPs in Water Use Category No. 7 (Dairy Animal Feed Preparation).

F. *Five Year Review of Best Management Practices*

Five years after an industrial user is accepted for regulation under the BMP Program, the director shall review the industrial user's BMPs to determine whether any changes in the BMPs are warranted. If the director determines that any of the existing BMPs are no longer appropriate due to an expansion of the dairy operation or a change in management practices at the operation, the director shall notify the industrial user in writing of that determination and the director and the industrial user shall make a good faith effort to stipulate to a modification of the BMPs so that they are appropriate for the expanded operation or the change in management practices.

If the director and the industrial user are unable to stipulate to a modification to the BMPs within 180 days after the director notifies the industrial user of the determination that one or more of the existing BMPs are no longer appropriate, or such longer time as the director may agree to, the industrial user shall no longer be regulated under the BMP Program, but shall thereafter be required to comply with the maximum annual water allotment conservation requirements set forth in section 6-702.

If the director and the industrial user stipulate to a modification of the BMPs, the industrial user shall comply with the modified BMPs by a date agreed upon by the director and the industrial user and shall continue complying with the modified BMPs until the first compliance date for any substitute conservation requirement in the Fourth Management Plan.

G. *Change in Ownership of Dairy Operation*

1. *If an industrial user regulated under the BMP Program sells or conveys the dairy operation to which the BMPs apply, the new owner of the dairy operation shall continue to be regulated under the BMP Program until January 1 of the first calendar year after acquiring ownership of the dairy operation. Except as provided in paragraph 2 of this section, beginning on January 1 of the first calendar year after acquiring ownership of the dairy operation, the new owner shall comply with the maximum annual water allotment conservation requirements set forth in section 6-702. The new owner may at any time apply for regulation under the BMP Program.*

2. *If the new owner submits a complete and correct application for regulation under the BMP Program prior to January 1 of the first calendar year after acquiring ownership of the dairy operation, the new owner shall continue to be regulated under the BMP Program until the director makes a determination on the application. If the director denies the application, the new owner shall be required to comply with the maximum annual water allotment conservation requirements set forth in section 6-702 immediately upon notification of the denial or January 1 of the first calendar year after acquiring ownership of the dairy, whichever is later. If the director approves the application, the new owner shall continue to be regulated under the BMP Program until the first compliance date for any substitute conservation requirement in the Fourth Management Plan.*

6-805. Monitoring and Reporting Requirements

For the calendar year 2002 or the calendar year in which water use is commenced at the dairy operation, whichever occurs later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirements in the Fourth Management Plan, an industrial user who uses water at a dairy operation shall include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water from any source, including effluent, withdrawn, diverted, or received during the calendar year, for use by the dairy operation as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

2. *The total quantity of water delivered during the calendar year to any uses other than the dairy operation from the well or wells which serve the dairy operation as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

3. *The total quantity of dairy wastewater delivered to grandfathered rights other than the dairy operation, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R-12-15-901, et seq.*

4. *The total number of lactating cows and non-lactating animals which were present on-site at the dairy operation on the last day of each month during the calendar year.*

5. *If the dairy operation is regulated under the BMP Program, any documentation as required by the director which demonstrates compliance with the program.*

6.8 CATTLE FEEDLOT OPERATIONS

6.8.1 Introduction

The Department regulates cattle feedlot operations that annually house a monthly average of 100 or more beef cattle per day. Water is primarily used for animal drinking and dust control.

6.8.2 Water Use by Cattle Feedlots

Cattle feedlot operations in the Phoenix AMA have non-irrigation grandfathered rights or groundwater withdrawal permits to withdraw more than 2,200 acre-feet of groundwater per year. In 1995, 800 acre-feet was pumped by feedlot operations. It is projected that the number and the water use of feedlot operations will not increase in the AMA. Historically, there has been a decline in the number of feedlot operations in the AMA due to urban encroachment.

The only component of cattle feedlot water use having a significant conservation potential is dust control watering. Cattle feedlots control dust by applying water to the land surface using either a mobile tank and large gun sprinkler, portable water lines with small nozzles, or a permanently installed sprinkler system. Each of these methods provides satisfactory dust control if water coverage is adequate and enough water is applied. If a permanent sprinkler system is installed, sprinkler heads should be selected and arranged to eliminate overspray, water application in excess of infiltration rates, and runoff.

Overall management of the system is the most important factor in efficient dust control watering. Many cattle feedlots could conserve water by using proper management techniques for their dust control water systems. Proper management techniques include removing excess manure to less than two inches in depth and increasing the number of cattle per pen to increase pen moisture. Dust can also be controlled by surfacing roads between pens. All of these management practices reduce dust, thereby reducing the need to apply water.

Conservation potential also exists in the areas of landscape watering and water system losses. Most cattle feedlot operations already use a float control system. Because this is the latest available conservation technology for cattle drinking water systems, no significant water savings can be achieved in that area.

6.8.3 Program Development

No conservation requirements for cattle feedlot operations existed during the first management period. Starting with the Second Management Plan, feedlots were assigned a maximum annual water allotment based on reasonable daily maximum requirements for animal drinking, dust control, and miscellaneous water use needs.

6.8.4 Cattle Feedlot Operation Conservation Program

The conservation requirements for cattle feedlot operations for the third management period remain unchanged from those in the Second Management Plan. The conservation requirements for cattle feedlot operations outlined in this management plan include a maximum annual water allotment for each facility based on the use of specific conservation technologies. For the Second Management Plan, representatives from the cattle feedlot industry and cattle feedlot experts from the University of Arizona College of Agriculture reviewed and verified that the equation used to determine the maximum annual water allotment for a feedlot allocates a reasonable amount of water to cattle feedlots.

The equation is based on the number of gallons of water reasonably required per animal per day (GAD). To determine this amount, three components of cattle feedlot water use were considered: (1) cattle drinking water requirements, (2) dust control watering requirements, and (3) other uses. The amount of water required for each component varies with the number of cattle processed by the feedlot. Drinking water requirements for cattle include water intake, water spilled while drinking, and evaporation losses from watering tanks. Drinking water requirements are estimated to be 15 GAD. Dust control watering requires approximately 10 GAD. Other uses, including water used for feed mixing, health and environmental controls, system losses, and fire protection total 5 GAD. Total water requirements for a cattle feedlot operation are 30 GAD. These requirements are continued for the third management period.

6.8.5 Future Directions

It is possible that more stringent air quality standards established during the third management period or beyond may require increased dust control measures for cattle feedlot operations. Water use for dust control may increase to comply with the standards. Fourth or fifth management period conservation requirements will need to be cognizant of any changes in this regard and make any necessary adjustments to the requirements.

6.8.6 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Cattle Feedlot Operations

6-801. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-802 through 6-803 of this chapter shall have the following meanings:

1. *"Beef cattle" means cattle or calves fed primarily for meat production.*
2. *"Cattle feedlot operation" means a facility that houses and feeds an average of 100 or more beef cattle per day during a calendar year as calculated in section 6-802.*

6-802. Maximum Annual Water Allotment Conservation Requirements

A. Maximum Annual Water Allotment

Beginning on January 1, 2002 or upon commencement of water use, whichever is later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user shall not withdraw, divert, or receive water for use at a cattle feedlot operation during a calendar year in a total amount that exceeds the cattle feedlot's maximum annual water allotment for the year as calculated in subsection B below.

B. Calculation of Maximum Annual Water Allotment

A cattle feedlot operation's maximum annual water allotment for a calendar year shall be determined as follows:

1. *Calculate the average daily number of beef cattle present during the calendar year. The director shall calculate the average daily number of beef cattle present during the calendar year as follows:*
   a. *Determine the total number of beef cattle present at the cattle feedlot operation on the last day of each month during the calendar year.*
   b. *Add together the total number of beef cattle present at the cattle feedlot operation on the last day of each month during the year in question and then divide the result by 12. The quotient is the average daily number of beef cattle present at the cattle feedlot operation during the calendar year.*
2. *Multiply the average daily number of beef cattle present at the cattle feedlot operation during the calendar year by a water allotment of 30 gallons per animal per day (GAD), and then convert to acre-feet per year as follows:*

$$C_B \times \frac{30\ GAD}{325{,}851\ g/acre\text{-}foot} \times d/yr = \text{Maximum annual water allotment for the cattle feedlot operation (acre-feet/year)}$$

Where: C_B = *Average daily number of beef cattle*
GAD = *Gallons per animal per day*
g/acre-foot = *Gallons per acre-foot*
d/yr = *Days in the year*

C. Compliance with Maximum Annual Water Allotment

An industrial user who uses water at a cattle feedlot operation is in compliance for a calendar year with the cattle feedlot operation's maximum annual water allotment if the director determines that either of the following applies:

1. *The volume of water withdrawn, diverted, or received during the calendar year for use at the cattle feedlot operation is equal to or less than the cattle feedlot operation's maximum annual water allotment for the calendar year; or*

2. *The three-year average volume of water withdrawn, diverted, or received for use at the cattle feedlot operation during that calendar year and the preceding two calendar years is equal to or less than the cattle feedlot operation's three year average maximum annual water allotment for that calendar year and the preceding two calendar years.*

D. *Nothing in this section shall be construed to authorize a person to use more water from any source than the person is entitled to use pursuant to a groundwater or appropriable water right or permit held by the person. Nor shall this section be construed to authorize a person to use water from any source, including effluent, in a manner that violates Chapter 1 or Chapter 2 of Title 45, Arizona Revised Statutes.*

6-803. Monitoring and Reporting Requirements

For calendar year 2002 or the calendar year in which water use is first commenced at the cattle feedlot operation, whichever occurs later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirements in the Fourth Management Plan, an industrial user who uses water at a cattle feedlot operation shall include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water from any source, including effluent, withdrawn, diverted, or received during the calendar year for use at the cattle feedlot operation as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

2. *The total number of beef cattle that were present on-site at the cattle feedlot operation on the last day of each month during the calendar year.*

6.9 NEW LARGE LANDSCAPE USERS

6.9.1 Introduction

New large landscape users are industrial users with substantial water-intensive landscaped area that was planted after January 1, 1990. The conservation program differentiates between two types of large landscape users: non-residential facilities that are hotels or motels and non-residential facilities that are not hotels or motels. If the facility is not a hotel or motel, conservation requirements apply to landscapable areas in excess of 10,000 square feet. If the facility is a hotel or motel, requirements apply to landscapable areas in excess of 20,000 square feet.

If a facility has ten or more acres of water-intensive landscaped area and is a school, park, common area within a housing subdivision, cemetery, or golf course, or is listed in Appendix 6B, it is defined as a turf-related facility and is subject to specific conservation requirements discussed in 6.3 of this chapter.

6.9.2 Water Use by New Large Landscape Users

Water use associated with landscaping is directly related to the size of the landscaped area, the types of vegetation planted, and the efficiency of the irrigation method used. Although low water use residential landscaping is becoming increasingly common in the Phoenix metropolitan area, significant water use is associated with the water-intensive landscaping of industrial parks, large commercial and institutional facilities, and resorts. Many municipal water providers have ordinances that place some conditions on new non-residential landscaping. While these ordinances have multiple objectives, they also have provisions that address water conservation. Some of these provisions include the placement of plants based on their water needs, the planting of low water use plants in certain areas, and the preservation of native vegetation.

No new large landscape users were identified during the second management period. While many large resorts and commercial facilities are constructed within water provider service areas, the potential exists for new facilities to have their own groundwater rights or permits. It is difficult to predict the growth of new large landscape users, but the potential for future facility construction and for significant water use will increase as the Phoenix area grows.

6.9.3 Program Development and Issues

Consultant studies conducted for the Second Management Plan indicated that significant reductions in landscape water use can be achieved using the following techniques:

- Improving water application efficiency through proper irrigation scheduling, using more sophisticated control systems, converting to drip irrigation, and grouping plants with similar water needs;
- Reducing the size and perimeter of turfed areas and limiting their placement to functional areas and areas of high visual impact;
- Using drought-resistant plant species adapted to the desert;
- Using proper planting, fertilization, and maintenance techniques;
- Grading sites to direct rainfall into planted areas; and
- Avoiding the use of water-intensive plants within rights-of-way, thus emphasizing the community's commitment to low water use designs.

The findings from these studies still apply for the third management period. A lush, colorful, low water use landscape watered by a permanent drip irrigation system is often considered more desirable for commercial and industrial landscape applications. This type of landscape results in water savings of 50 to 75 percent of the amount used by a well-maintained turf (water-intensive) landscape.

The distinction in the program between hotel or motel landscapes and landscapes that are associated with facilities that are not hotels or motels is intended to address the contention by the lodging industry that for certain hotel and motel developments there is an economic benefit from planting high water use landscape plant material, thus economically justifying a larger water-intensive area.

6.9.4 New Large Landscape User Program

The new large landscape user program for the Third Management Plan is similar to that in the Second Management Plan. In addition to the requirements that apply to all industrial users, new large landscape users must limit the percentage of water-intensive landscaped area above a specified square footage. The facility must limit its water-intensive landscaped area to the greater of the following: 1) 10,000 square feet (20,000 square feet for hotels and motels) plus twenty percent of the area in excess of 10,000 square feet (20,000 square feet for hotels and motels); and 2) the total surface area of all bodies of water within the facility that qualify as water intensive landscaped area.

Water-intensive landscaping includes not only high water using plants such as turf, but also bodies of water such as ponds. However, it does not include any area of land watered exclusively with direct use effluent or effluent recovered within the area of impact, bodies of water used primarily for swimming, bodies of water filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact and bodies of water allowed under an interim water use permit pursuant to the Lakes Bill if the body of water will be filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact after the permit expires. Direct use effluent or effluent recovered within the area of impact is effluent that is either used directly or is stored underground and then recovered within the area of impact. If 100 percent wastewater is used to water the landscape, the requirements do not apply. For example, if there is sufficient cooling tower blowdown water and greywater available from the operations of a hotel, this wastewater could be used to water any amount of water-intensive landscaped area up to 10 acres. Once a water-intensive landscaped area equals or exceeds 10 acres in size, it is defined as a turf-related facility and is subject to regulation under that program.

6.9.5 Non-Regulatory Efforts

The Phoenix AMA has funded a grant that involves researching different drip irrigation methods for watering low water use landscaping. The goal is to ascertain the appropriate number, placement, and capacity of drip irrigation systems during the life cycle of low water using plants and trees. Information for efficiently managing low water use landscaping while maintaining a lush appearance may encourage more industrial users to adopt low water use landscaping instead of water-intensive landscaping where feasible.

Grant projects with the City of Chandler will research the use of cooling tower blowdown water and industrial process water to irrigate landscape plants. It is possible that findings from the research will be transferable and will be able to be widely implemented.

6.9.6 Industrial Conservation Requirements and Monitoring and Reporting Requirements for New Large Landscape Users

6-901. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-902 and 6-903 of this chapter shall have the following meanings:

1. *"Direct use effluent" means effluent transported from a facility regulated pursuant to Title 49, Chapter 2, Arizona Revised Statutes, to an end user. Direct use effluent does not include effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes.*

2. *"Effluent recovered within the area of impact" means effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes, and recovered within the stored effluent's area of impact. For purposes of this definition, "area of impact" has the same meaning as prescribed by A.R.S. § 45-802.01.*

3. *"Landscapable area" means the entire area of a lot less any areas covered by structures, parking lots, roads, or any other area not physically capable of being landscaped.*

4. *"New large landscape user" means a non-residential facility that has a water-intensive landscaped area in excess of 10,000 square feet and that has landscaping planted and maintained after January 1, 1990 or bodies of water, other than bodies of water used primarily for swimming purposes, filled and maintained after January 1, 1990, or both. Turf-related facilities as defined in section 6-301 of this chapter are excluded from this definition.*

5. *"Water-intensive landscaped area" means, for the calendar year in question, all of the following areas within a non-residential facility:*

   a. *Any area of land that is planted primarily with plants not listed in Appendix 5-L, Low Water Use/Drought Tolerant Plant List, Phoenix AMA, or any modifications to the list, and watered with a permanent water application system, except any area of land that is watered exclusively with direct use effluent or effluent recovered within the area of impact.*

   b. *The total water surface area of all bodies of water within the facility, except bodies of water used primarily for swimming purposes, bodies of water filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact, and bodies of water allowed under an interim water use permit pursuant to A.R.S. § 45-133 if the bodies of water will be filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact after the permit expires.*

6-902. Conservation Requirements

A. Conservation Requirements for New Large Landscape Users that are not Hotels or Motels

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, the water-intensive landscaped area within a new large landscape user that is not a hotel or motel shall not *exceed the greater of the following: 1) an area calculated by adding 10,000 square feet plus 20 percent of the facility's landscapable area in excess of 10,000 square feet; and 2) the total water surface area of all bodies of water within the facility that are allowed under A.R.S. § 45-131, et seq., and that qualify as water-intensive landscaped area.*

B. Conservation Requirements for New Large Landscape Users that are Hotels or Motels

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, the water-intensive landscaped area within a new large landscape user that is a hotel or motel shall not exceed the greater of the following: (1) an area calculated by adding 20,000 square feet plus 20 percent of the facility's landscapable area in excess of 20,000 square feet; and (2) the total water surface area of all bodies of water within the facility that are allowed under A.R.S. § 45-131, et seq., and that qualify as water-intensive landscaped area.

C. Waiver of Conservation Requirements for the Use of 100 Percent Wastewater

The conservation requirements set forth in sections 6-902.A and B shall not apply to a new large landscape user in any year in which all of the water used for landscaping purposes within the facility is wastewater.

6-903. Monitoring and Reporting Requirements

For calendar year 2002 or the calendar year in which the facility first begins to use water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user that applies water to a new large landscape user shall include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water from any source, including effluent, withdrawn, diverted, or received for use on the facility during the reporting year for landscape watering purposes, including bodies of water filled or refilled during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-90,1 et seq.*

2. *The total amount of landscapable area within the facility.*

3. *The total amount of water-intensive landscaped area at the facility broken down into the area planted primarily with plants not on the Low Water Use/Drought Tolerant Plant List (except any area watered exclusively with direct use effluent or effluent recovered within the area of impact) and the surface area of all bodies of water (except bodies of water used primarily for swimming purposes, bodies of water filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact, and bodies of water allowed under an interim water use permit if the bodies of water will be filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact after the permit expires).*

6.10 NEW LARGE INDUSTRIAL USERS

6.10.1 Introduction

New large industrial users are industrial users that use over 100 acre-feet per year and commence use after January 1, 2000. In the Second Management Plan, new large industrial users were defined as industrial users that use over 100 acre-feet of water per year and commenced use after January 1, 1990. As of August, 1998, six new large industrial users had been identified during the second management period in the Phoenix AMA that are not industrial users subject to specific conservation requirements discussed elsewhere in this chapter.

6.10.2 Water Use Characteristics and Trends

In 1995, there were six industrial facilities in the Phoenix AMA, other than cattle feedlots, sand and gravel facilities, turf-related facilities, electric power plants, and dairy operations that individually used more than 100 acre-feet of water during the year. The six facilities are mining, integrated circuit manufacturing, milling, defense systems, ice manufacturing, and riparian areas maintained by the Arizona Game and Fish Department. The combined water use of these facilities during 1995 was approximately 3,100 acre-feet. This use was pursuant to nine Type 2 non-irrigation grandfathered rights with allotments totaling 8,560 acre-feet. An additional 15 grandfathered rights and groundwater withdrawal permits withdrew over 100 acre-feet in 1995 but commenced operation prior to January 1, 1990. Another 84 grandfathered rights and withdrawal permits have allotments over 100 acre-feet per year; these rights and permits are either being used to withdraw less than 100 acre-feet per year or are not being used at all. The combined allotments for these rights and permits total over 48,500 acre-feet. Although some of this large volume could potentially be used to serve new large industrial users, the number and water use of additional new large industrial users is difficult to predict. New large commercial or manufacturing facilities are often constructed within service areas of municipal water providers and become their customers.

6.10.3 Program Development and Issues

No requirements for new large industrial users existed in the First Management Plan. The Second Management Plan contains a specific conservation requirement for new industrial users that use over 100 acre-feet of water per year. New industrial users were required to prepare and submit a water conservation plan that addresses the water conservation opportunities at the facility. The user is required to develop a plan that:

- Describes the level of water conservation that can be achieved;
- Identifies the water uses and conservation opportunities within the facility;
- Describes an ongoing water conservation education program for employees; and
- Includes an implementation schedule.

The Department has determined that a conservation plan is a reasonable requirement to continue in the third management period, considering the large volume of unused allotments that could be used for new large industrial uses and the corresponding opportunity to design water conservation into new or expanding facilities. When facilities expand, even after operation has commenced, there are additional water conservation opportunities associated with being able to "build in" water-conserving designs. This is typically more economical and more feasible than retrofitting a facility that is not expanding.

6.10.4 New Large Industrial User Program

The new large industrial user program for the third management period is identical to that of the second management period. In addition to the conservation requirements that apply to all industrial users, new large industrial users must prepare and submit a water conservation plan to the director. However, if the user is required to submit a conservation plan under another section of this chapter, it can combine the plans and submit one plan.

The water conservation plan must show how much conservation can be achieved at the facility. It must identify how water is used at the facility and how it can be conserved in major water use areas. The plan must also describe an employee water conservation education program at the facility and a schedule of implementation of the conservation measures.

6.10.5 Industrial Conservation Requirements and Monitoring and Reporting Requirements for New Large Industrial Users

6-1001. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes and section 6-201 of this chapter, "new large industrial user" means an industrial user that begins using more than 100 acre-feet of water per year for industrial purposes after January 1, 2000.

6-1002. Conservation Requirements

A. *Not later than January 1, 2002 or within 180 days after the end of the first calendar year in which the facility first uses more than 100 acre-feet of water for industrial purposes, whichever is later, a new large industrial user shall submit to the director a plan to improve the efficiency of water use by the facility. The plan shall:*

1. *Specify the level of water conservation that can be achieved assuming the use of the latest commercially available technology consistent with reasonable economic return;*

2. *Identify water uses and conservation opportunities within the facility, addressing water used for the following categories as appropriate: landscaping; space cooling; process-related water use, including recycling; and sanitary and kitchen uses;*

3. *Describe an ongoing water conservation education program for employees; and*

4. *Include an implementation schedule.*

B. *If a person required to submit a plan under subsection A of this section is required to submit a conservation plan under another section of this chapter, the person may combine the plans into a single conservation plan.*

REFERENCES

Brown, P., Gilbert, J., and D. Kopec, 1996. *Final Report to the Arizona Department of Water Resources, Turfgrass Irrigation Scheduling Using Weather Based Estimates of Evapotranspiration for High and Low Traffic Turfs.* Contract No. CA94TU103-00, May 31, 1996.

APPENDIX 6A
CONSERVATION ALTERNATIVES FOR TURF-RELATED FACILITIES
PHOENIX ACTIVE MANAGEMENT AREA

The Department conducted a study of conservation technologies and management techniques available to turf-related facilities. These conservation alternatives are categorized into:

A. Incorporation of conservation considerations into the facility design,
B. Irrigation technologies,
C. Irrigation scheduling and management,
D. Turf management options,
E. Pond and reservoir management, and
F. Turf maintenance staff education.

A. FACILITY DESIGN	DESCRIPTION / CONSERVATION POTENTIAL
1. General	Develop a master plan for the design (for new facilities) or redesign (for existing facilities) that incorporates water conserving elements. An important element of a facility designed with water efficiency in mind is adequate irrigation design. A well designed and properly installed irrigation system reduces water use and results in a high quality and attractive turf and landscape. In addition to what is listed below, the irrigation technologies, turf selection, and pond/reservoir construction guidelines outlined in sections B through F below are all relevant for designing or redesigning turf-related facilities with water conservation as a goal.
2. Golf Courses	
a. Minimize and level turf; use cart paths	Design measures include: narrow fairways, reduced fairway length, more tee choices per hole, less rough area, smaller greens, flatter courses, fewer slopes, no turf in front of tees, a complete cart path system, and zero lot line fairways placed side by side. Smaller greens, tees, roughs, and fairways reduce total irrigation water demand. Flatter courses have less water loss from runoff than sharply sloped courses. A cart path system reduces soil compaction and wear and tear on the turf.
b. Water harvesting	Use catch basins to divert storm water and runoff to storage ponds; perforate the pipe collection system to funnel water to storage ponds; slope fairways toward ponds; design cart paths to drain into lake; and collect water from adjacent developments. Water harvesting allows for increased reuse of irrigation water and the retention of "free" water on-site.

A. FACILITY DESIGN	DESCRIPTION / CONSERVATION POTENTIAL
c. Zone areas of different water demand separately	Areas to zone: level and sloped areas; windy and protected areas; tees, greens, fairways and rough; turf and non-turf areas; soils with different percolation rates; separate, difficult-to-manage areas; shady and non-shady areas. Incorporate separate valving for zoned areas. This reduces the amount of water lost to evaporation, runoff, and percolation below the root zone and eliminates over-watering to accommodate dry or hard-to-irrigate areas. It is especially important for new design.
d. Individualized head layout that responds to facility configuration	Use small heads on tees and greens, 1/2-circle heads at edge of turf area. Eliminates runoff and over-irrigating to compensate for dry areas.
e. Looped lateral system	Has a lower pressure differential than a linear irrigation system. Improves the uniform distribution of irrigation water. Lower differential between wet and dry spots.
f. Use of vegetative or other wind barriers	Reduces evaporation.
g. Involve golf course superintendent in original design	Application of water conservation methods and techniques gained through hands-on experience.
h. Use native or low water use landscaping in non-turf areas	Low water demand plant materials reduce amount of water needed to irrigate non-turf areas.
i. Design facility to ensure compliance with Department requirements	Minimizes probability that facility will use more than the maximum annual allotment.
j. Design facility to accommodate effluent as source water	Separate turf/landscaping distribution system from potable distribution system. Select valves, heads, emitters, etc. that are able to function easily with effluent quality water.
3. Non-Golf Course Turf Facilities	
Maximize areas of low water use plants and inorganic mulches in non-play/minimal use areas	Less turf area being used; less area to irrigate.

B. IRRIGATION TECHNOLOGIES	DESCRIPTION / CONSERVATION POTENTIAL
1. Controllers	Controllers regulate irrigation scheduling. The controller activates a valve at a preset time and turf is irrigated for a preset period of time. Each valve controls one set of sprinkler heads. The number of controllers and valve stations depends on the area of turf, the size of the valve, and the design of the irrigation system. The use of controllers does not guarantee water savings, but when programmed and operated by an experienced manager they are a good conservation tool.
a. Electromechanical controllers	A motor turns rotary switches that activate relays. While the least efficient of the controllers, these low cost controllers can result in a 30 to 40 percent water savings over quick coupler systems.
b. Centralized system controller	Quick, accessible control over entire facility's irrigation scheduling.
c. Solid-state controllers	Electronic accuracy -- precision irrigation application and timing, individual station programing, multicycling, multiple programming, longer station timing for drip irrigation, capability to interface with a rain shut-off switch or wind sensor.
d. Computerized controllers	The most sophisticated and accurate method of irrigation timing available, but costs make it appropriate only for larger facilities. Real-time water budgeting capabilities are its most important feature. Specific features include: (1) individual stations can be controlled, (2) operator can precisely limit water to desired saturation point eliminating runoff and percolation below the root zone, (3) historical evapotranspiration (ET) rates can be programmed into scheduling, (4) can interface with weather monitoring system and current reference ET and soil moisture information, and (5) pinpoints excess flows by station.
2. Heads	There are a wide variety of head and nozzle choices available to fit specific irrigation needs. Properly selected heads and nozzles determine the uniformity of coverage and eliminate overspray, water application in excess of infiltration rates, runoff, and evaporation. Matched precipitation rates allow uniform application of irrigation water. Select head size according to turf area.
a. Valve in head sprinklers or one valve - one head	Allow for pinpoint irrigation accuracy for large turf areas and irrigation zoning. Drawbacks are that they reduce the ability to use rain shut-off switches and do not allow the controller to regulate/ coordinate with the rest of the system.

B. IRRIGATION TECHNOLOGIES	DESCRIPTION / CONSERVATION POTENTIAL
b. Low volume/low pressure spray heads	Prevents runoff, wind distortion, and evaporation from standing water in areas with a low infiltration rate for smaller turf areas; improves uniformity; reduces application rates; and allows larger areas to be irrigated with a given amount of water. Lower differential between wettest and driest spots.
c. Low trajectory heads	Prevents wind distortion, evaporation.
d. Gear driven heads	More uniform water application.
e. Pressure compensating bubblers	More uniform water application in non-turf areas.
f. Matched precipitation rate heads	Allows more uniform irrigation coverage when grouped with similar pattern heads.
3. Valves	
a. Electric valves	Precise irrigation timing.
b. Check valves	Prevents low head drainage, wet areas around heads, and backflow.
c. Master valve	Opens when system is operated; closed system completes cycle. Installed above all automatic valves. Valve prevents discharge of water, except when system is in a running cycle, as in the case of a break in the line or a malfunctioning valve.
4. Sensors	
a. Automatic rain shut-off switch	System shuts down when rainfall exceeds a preselected amount with automatic return to schedule when water in collector evaporates; prevents overwatering. Interfaces with central controller or satellite controllers.
b. Wind sensor	System shuts down when wind speed reaches a preset velocity at which wind draft and evaporation are excessive. Cycle resumes when wind speed tapers off.
c. Soil moisture sensor	Allows more precise adjustment of time and frequency of irrigation. Eliminates excessive water application. Low utility on large turf areas because of too much variability. Can be directly wired to controller for more automatic use. Portable soil probes useful for checking localized dry spots. Good for an analysis of system efficiency.
d. Infrared sensor	Allows assessment of plant water needs through use of infrared light.
5. Other	
a. Drip irrigation of non-turf areas	Water applied where needed. Non-turf application. Eliminates evaporation. Significant water savings. Also yields improved plant growth.

B. IRRIGATION TECHNOLOGIES	DESCRIPTION / CONSERVATION POTENTIAL
b. Excess flow-sensing device/ low pressure shut off switch	Prevents water waste. Sensitive to low pressure caused by breaks in the line or a missing head. Shuts system down in event preset pressure is reached.
c. Flow meter	Permits accurate measurements of water use to facilitate irrigation scheduling and budgeting.
d. Pressure regulators	Permits maintenance of design pressure, eliminates evaporation and wind drift because of head misting. Especially important for drip systems.

C. IRRIGATION SCHEDULING AND MANAGEMENT	DESCRIPTION / CONSERVATION POTENTIAL
1. Irrigation Program Techniques	An effective combination of the following irrigation techniques will help eliminate evaporation, runoff, and water application in excess of the infiltration rate.
a. Deep irrigation and longer periods between irrigations to develop root system	Turf with a well developed root system can endure more stress. Turf can exploit more stored water. Good soil infiltration and percolation is required.
b. Deficit irrigation	Deficit irrigation involves keeping turf somewhat stressed to develop a deep root system. Irrigation frequency can be adjusted to reduce consumptive water demand of turf. Turf with a well developed root system can endure more stress and can exploit water stored in deeply wetted soil profile. Research is needed to determine which turf types adjust the most favorably to deficit irrigation. Turf under deficit regime can survive more easily if no other stress is added. Requires careful management. Especially appropriate for less intensely used areas such as roughs and fairways.
c. Short, repeat irrigation cycles (cycle and soak)	Prevents runoff on sloped areas. Prevents evaporation of standing water in areas with low infiltration rates. Eliminates excess water applications. More effective in cool season because of low evaporation rates. Can only be done efficiently with a solid state controller. Useful on compacted soils and for germinating rye grass.
d. Daily visual inspection to assess water needs	Irrigation can be evaluated by micro-areas, irrigation adjustments can accommodate area differences. Instant adjustments can be made to accommodate wet spots and dry spots. Dew patterns can be observed in the early morning to detect abnormal head spray patterns.
e. Night irrigation	Less wind distortion, less evaporation, ET rate at the lowest point of the day. Need automatic controllers to be effective.

C. IRRIGATION SCHEDULING AND MANAGEMENT	DESCRIPTION / CONSERVATION POTENTIAL
f. Daily logging of local or on-site weather conditions or use of a controller that is linked to an on-site weather station	Assesses irrigation needs to permit a more exact irrigation application on a daily basis. Allows application of water to exactly compensate for water used that day. Permits long-term irrigation scheduling and budgeting.
g. Use of soil tests to determine soil characteristics, especially percolation rate, available water capacity, degree of soil compaction, and nutrient requirements	Knowing soil characteristics permits matching of percolation rate and irrigation rate, reduces evaporation and runoff, and avoids applying more water than can be held in the root zone or deeper than necessary. Signals need for treatment of soil compaction. Provides accurate information for computation of gypsum or sulphur requirement and for precise replacement of nutrients.
h. Manually irrigate small dry spots - use quick coupler hose or other manual method	Eliminates overwatering by using a set of heads or one large radius head to wet a small area.
2. Irrigation equipment maintenance	A routine preventative maintenance program for irrigation equipment results in the decrease of water loss and misapplication of water.
a. Heads	Check for wear, clogging, check pattern for consistency. Check after mowing for breaks. Adjust nozzles and heads as needed. Replace broken or worn parts.
b. Pipes	Check for leaks or breaks. Repair or replace as needed.
c. Valves	Check for leaks, sticking, buried or exposed wires, protect wiring. Replace or fix as needed. Promotes exact station timing control.
d. Controllers	Check for correct timing, sticking, non-functioning. Fix or replace as needed. Replace backup batteries at least once a year (or after each power failure).
e. Meters	Check meters for accuracy and sticking. Repair as necessary. Prevents mismeasurement of irrigation water. Improves water budgeting capability.
f. Pressure	Maintain design pressure. Readjust valve flow or replace pressure regulators as necessary. Prevents water loss through leaks, evaporation.
3. Water Use Planning	
a. Water budgeting	Use historical weather patterns, use local ET rate for turfgrasses, measure use against budget, adjust use accordingly. Regulates water use at a prescribed level. Allows operator to ensure compliance with annual allotment.

C. IRRIGATION SCHEDULING AND MANAGEMENT	DESCRIPTION / CONSERVATION POTENTIAL
b. Accurate measurement	Daily measurement of water use using pump flow meter (gallons per minute), measurement by computerized controller system, or hour meter in conjunction with flow capacity. Allows manager to keep accurate water use records. Use to compare with established goal and to evaluate performance.
c. Accurate records	Daily logging of water use and weather conditions. Monthly water use reports. Allows manager to assess historical water use and weather data for use in future irrigation budgeting.
d. Establish irrigation priorities for periods of water shortage	Enables manager to plan for seasonal water requirements.
e. Separate metering of landscape water use	Allows manager to keep accurate water use records.
f. Use landscape water management software	Software can calculate an efficient irrigation schedule.
4. Non-Groundwater Source Water	
Use effluent whenever feasible	Replacing groundwater pumpage with effluent use constitutes a water conservation management option. Existing nutrients in effluent (especially nitrogen) may reduce fertilizer needs. Operational concerns associated with effluent use (additional leaching needs due to salts, clogged emitters, etc.) require special attention. Many existing facilities are successfully using effluent in place of groundwater.

D. TURF MANAGEMENT OPTIONS	DESCRIPTION / CONSERVATION POTENTIAL
1. Turf Selection	
a. Select turf for low water demand	Hierarchy of turf types from highest to lowest water demand: (warm season grasses) bent grass, hybrid bermuda, common bermuda, desert and range grasses; and (cool season grasses) annual rye and perennial rye.
b. Select non-traditional turf or non-turf alternatives for rough and non-play areas	Choose blue gramma, schismus, three-awn, buffalo grass, vine mesquite, curly mesquite, and/or giant mesquite, and/or giant bermuda
c. In cool seasons, select non-turf alternative for fairways and rough	Options include: Leave turf dormant; use ferrous sulfate; dye dormant turf green; apply liquid fertilizer to turf to aid chlorophyll production in frost-free areas. Eliminates late fall/winter water use associated with overseeding with rye. Some irrigation necessary to keep dormant grasses tough and wear resistant. Keeps bud nodes from drying out, prevents desiccation. Rye grass uses approximately 8-10 inches of extra water per year.
2. Winter Overseeding	
a. Time winter overseeding by soil temperature, not calendar dates	Most favorable soil temperature for overseeding is between 72 and 78 degrees Farenheight, at a 4-inch depth. Overseeding at these lower temperatures decreases water use and evaporation, leads to a minimal fall transition period with less competition from bermuda.
b. Eliminate total scalping of summer turf	When scalped, bermuda has a difficult time coming back in the spring and requires more water and fertilizer to do so, especially hybrid bermuda. Aerate and apply gypsum if needed to reduce salts before seeding to improve infiltration rate. Reduces runoff, evaporation from standing surface water. Increases water, air, fertilizer penetration into the root zone.
3. Turf Removal	
Develop a master plan for turf removal	Turf alternatives include: desert revegetation, drought tolerant ornamental planting, desert and range grasses, and desert flowers. Permanently reduces turf water use on specific areas.
4. Fertilizer	Healthy, well-fed turf tends to have a better developed root system to balance fertilizer needs with water demand. This reduces overall water demand. Over fertilizing, however, can result in higher water requirements because of faster growth rate.
a. Use less nitrogen to retard turf growth	Turfgrass ET rate decreases with slower turf growth rate. Water demand decreases as ET rate decreases.

D. TURF MANAGEMENT OPTIONS	DESCRIPTION / CONSERVATION POTENTIAL
b. Use slow release fertilizers during warm season	Reduces growth spurts that increase water demand. Eliminates peaks and valleys of turf growth.
c. Use soil tests to assess fertilizer needs	A more precise application of fertilizer reduces growth spurts that increase water demand.
d. Apply nitrogen in the fall to cool season turfgrasses	Avoid application at time of spring green-up of warm season turf. Decreases early water demand of warm weather turf.
e. Monitor potassium levels and keep readily available in periods of high temperature and drought stress	Permits turf to resist stress. Reduces turfgrass wilting tendency.
f. Apply dry fertilizers when feasible	Avoids water needs associated with liquid applications.
g. Apply growth regulators as fertilizer	Grass blades grow horizontally rather than vertically, reducing ET rate.
5. Soil Compaction and Low Permeability	Compaction is a problem for all turf areas, except areas with very sandy soil. Infiltration, percolation, aeration, and plant available moisture are altered by soil compaction. Water use efficiency is enhanced in non-compacted soils. Changes in soil structure cause water loss by evaporation and runoff, in addition to influencing plant growth. Causes reduced root growth.
To alleviate soil compaction and improve soil permeability:	
a. Aerate	Soil cultivation enhances infiltration, percolation, and soil moisture content. Permits water, air, and chemicals to reach root zone of turf.
b. Use soil tests to assess soil salinity and pH	High salinity increases potential for runoff, reduces infiltration and percolation rate. High pH increases water demand.
c. Apply gypsum	Replaces sodium in the soil and allows it to leach out. Improves infiltration and percolation.
d. Apply sulphur or sulphuric acid	Lowers pH of soil.
e. Control high traffic areas	Reduces compaction. Options include: Change traffic pattern; restrict traffic from specific areas; restrict carts to cart paths; smaller, more frequent applications in high traffic areas.
f. Install cart paths	Paths should be installed throughout golf course or at least in heavily traveled areas (e.g., around greens and tees). Reduces impact of cart traffic on soil structure, reduces compaction.

D. TURF MANAGEMENT OPTIONS	DESCRIPTION / CONSERVATION POTENTIAL
g. Apply wetting agents	Can be applied manually or injected automatically through the irrigation system. Increases infiltration rate. Especially useful for sandy soils that have developed a hydrophobic condition.
h. Use geotextiles, plastic, or concrete pavers cut out for turf	Relieves wear and tear on soil structure and turf. Reduces soil compaction.
I. Apply rules, such as the 90° rule, to minimize cart traffic on fairways	Reduces compaction.
6. Turf Damage	
a. Keep carts off turf during hot periods to reduce tire wilt	Wilted turf has a higher water demand. Damaged turf requires water to bring it back.
b. Control number of golf rounds played on hot days	Relieves stress on turf; reduces use of extra irrigation water to bring turf back.
c. Allow for maximum recovery time of turf before using muddy or damaged areas	Reduces damage from soil compaction; reduces use of extra irrigation water to bring turf back.
7. Thatch Control	
Institute a systematic thatch control program	Methods to control thatch include: verticutting, slicing, and spiking. Thatch increases the potential for runoff, decreases the infiltration rate, raises water demand.
8. Mowing Practices	
Incorporate turf mowing practices that reduce ET rate	A few practices are: mow turf at prescribed height; use reel mower; use sharp mower blades; mow frequently; do mowing late day or night. Mowing practices are dependent on use and budget. Turf grass water use increases with mowing height and declines with mowing frequency.

E. POND AND RESERVOIR MANAGEMENT	DESCRIPTION / CONSERVATION POTENTIAL
1. Surface Area	
a. Eliminate ponds or reservoirs that are not being used for storage	Reduces evaporation and seepage.
b. Decrease pond surface area to depth ratio	Reduces evaporation.
c. Use chemical surface coating or mechanical covers	Reduces evaporation.
2. Seepage	
a. Drain pond and reline with heavy duty plastic film and/or concrete	Most efficient method to eliminate pond leakage. PVC liners completely eliminate seepage.
b. Convert open streams and channels that deliver irrigation water to covered pipelines	Eliminates evaporation and seepage.

F. TURF MAINTENANCE STAFF EDUCATION	DESCRIPTION / CONSERVATION POTENTIAL
1. Staff Hiring, Retention and Education	Good management involves all staff members at a facility.
a. Staff education	Staff education should focus on water conservation, irrigation techniques, and irrigation technology. Encourage, support financially, and give time off for seminars and workshops on water conservation and irrigation techniques.
b. Promote in-house	Staff retention yields more employees skilled in water conservation techniques.
c. Pay adequate salaries	Decreases staff turnover, retains staff skilled in water conservation techniques.
d. For large turf-related facilities, hire an irrigation manager whose sole responsibility is irrigation and turf management	Irrigation manager can concentrate on irrigation and water conservation.
e. Create operators conservation incentive	Give bonus calculated on water saved.
f. Hire staff with education and experience in agronomic area	Irrigation and turf management skills and education assist in successful water conservation efforts.

APPENDIX 6B
TURF-RELATED FACILITIES
PHOENIX ACTIVE MANAGEMENT AREA

Parks

Amberwood Park
Arrowhead Meadows Park
Barrios Unidos Park
Benedict Park
Cactus Park - Phoenix
Cactus Park - Scottsdale
Carriage Lane Park
Cave Creek Park
Chandler Sports Complex
Chaparral Park - Glendale
Chaparral Park - Scottsdale
Cesar Chavez Park
Cielito Park
Circle K Park
Conocido Park
Cortez Park
Coyote Basin Park
Crossed Arrows Park
Daley Park
Deer Valley Park
Desert Breeze Park
Desert Foothills Parks
Desert Horizon Park
Desert Star Park
Desert West Sports Complex
El Dorado Park
El Oso Park
El Prado Park
El Reposo Park
Emerald Park
Encanto Park
Esteban Park
Estrella Mountain Regional Park
Fitch Park
Folley Park
Fountain Park
Freestone Park
Gene Autry Ballpark
Granada Park
Greenfield Park
Grovers Park
Harmony Park
Harry Bonsall Sr. Park
Heritage Park
Hermosa Park
Hohokam Park
Holmes Retention Basin
Hoopes Park
Indian School Park - Phoenix
Indian School Park - Scottsdale
Jefferson Park
Kingsborough Park
Kiwanis Park
Kleinman Park
La Pradera Park
Little Canyon Park
Los Alamos Park
Los Olivos Park
Madison Park
Margaret T. Hance Park
Mariposa Park
Marivue Park
Maryvale Baseball Facility
Maryvale Park
McCormick Railroad Park
McKellips Lake and Vista del Camino
Moon Valley Park
Mountain View Park - Chandler
Mountain View Park - Mesa
Mountain View Park - Phoenix
Mountain View Park - Scottsdale
Old Crosscut Canal Linear Park
Optomist Park
Palo Verde Park
Papago Baseball Facility
Papago Park - Tempe
Paradise Cove Park
Paradise Valley Park
Peoria Sports Complex
Pierce Park
Pima Park
Pioneer Park
Red Mountain Park
Reed Park
Rio Salado Park
Riverview Park
Roadrunner Park
Rose Lane Park
Rose Mofford Sports Complex
Royal Palm Park
Saguaro Ranch Park
Sandpiper Park
Scottsdale Ranch Park
Sereno Park
Shawnee Park
Sherwood Manor Park

Silvergate Park
Sonrisa Park
Sueno Park
Sun Ray Park
Sunburst Paradise Park
Sunnyslope Park
Sunridge Park
Sweetwater Park
Tempe Diablo Stadium
Turtle Rock Basin
Venturoso Park
Victory Lane Sports Complex
Vista Canyon Park
Washington Park
West World

Schools

Agua Fria Union North High School
Aqua Fria Union South High School
Alhambra High School
Apache Junction Junior High School
Apache Junction High School
Apollo High School
Arcadia High School
Arizona State University
Avondale Elementary School - Central
Avondale Elementary School - La Canada
Barcelona North and South Elementary Schools
Barry Byron Elementary School
Barry Goldwater High School
Bicentennial North and South Elementary Schools
Bogle Junior High School
Bourgade Catholic High School
Brimhall Junior High School
Buckeye Union High School
Cactus High School/Foothills Elementary School
Cactus Shadows High School/Desert Arroyo Middle School
Camelback High School
Carl Hayden High School
Cartwright Elementary School
Central High School
Chandler High School
Chaparral High School
Cherokee Elementary School
Clarendon Elementary School
Cochise Elementary School
Cocopah Middle School
Coronado High School
Cortez High School
Deer Valley High School/Desert Sky Middle School
Desert Horizon Elementary School
Desert Sands Junior High School
Desert Shadows Middle School
Dobson High School
Don Mensendick Elementary School/ William C. Jack Elementary School
Dysart Middle School
El Mirage Elementary School
Erie Elementary School
Estrella Middle School
Fees Junior High School/Rover Elementary School
Frank Borman Middle School
Fremont Junior High School
Frye Elementary School
Galveston Elementary School
Gilbert Elementary School/Mesquite Junior High School
Gilbert Junior High School
Gililland Junior High School
Glenn F. Burton Elementary School
Glendale American Elementary School
Glendale Community College
Glendale High School
Glendale Landmark Middle School
Grand Canyon University
Greenfield Junior High School/Kennedy Elementary School
Greenway High School
Greenway Middle School
Harold W. Smith Elementary School
Heatherbrae Elementary School
Hendrix Junior High School
Hohokam Elementary School
Holiday Park Elementary School
Horizon Elementary School
Horizon High School
Independence High School
Kino Junior High School
Knox Elementary School
Kyrene del Pueblo Middle School/Kyrene de la Paloma Elementary School
Kyrene Middle School/C.I. Waggoner Elementary School
Litchfield Elementary School
Luke Elementary School
Madison Park Elementary School
Marcos de Niza High School

Maryvale High School
McClintock High School
Melvin E. Sine Elementary School
Mesa Community College
Mesa High School/Franklin East Elementary School
Mesa Junior High School/Lowell High School
Mohave Middle School
Moon Valley High School
North Canyon High School
O'Connor Elementary School
Paradise Valley High School
Peoria High School
Peralta Elementary School
Phoenix College
Pima Elementary School
Poston Junior High School/Field Elementary School
Powell Junior High School/Redbird Elementary School
Pueblo Elementary School
Queen Creek Middle School and Elementary School
Red Mountain High School
Rhodes Junior High School
Saguaro High School
Salk Elementary School
Seton Catholic High School
Sevilla Elementary School
Shadow Mountain High School
South Mountain Community College
South Mountain High School
Stapley Junior High School
Starlight Park Elementary School
Sunnyslope High School
Sunrise Middle School/Liberty Elementary School
Sunrise Mountain High School
Supai Middle School
Taylor Junior High School/Irving Elementary School
Tempe High School
Thunderbird-The American Graduate School of International Management
Thunderbird Adventist Academy
Thunderbird High School
Tolleson Junior High School
Tolleson Union High School
Trevor G. Browne High School
Villa de Paz Elementary School
Washington High School
Western Sky Middle School
Westview High School
Westwood High School/Carson Junior High School/Emerson Elementary School
Willis Junior High School

Golf Courses

Adobe Dam Family Golf Center
ASU Karsten Golf Course
Ahwatukee Country Club
Alta Mesa Country Club
Ancala Country Club
Apache Creek Golf Club
Apache Sun Golf Club
Apache Wells Country Club
Arizona Biltmore Country Club
Arizona Country Club
Arizona Golf Resort
Arrowhead Country Club
Augusta Ranch Golf Course
Bellair Golf Course
Boulders Golf Course, The
Briarwood Country Club
Camelback Golf Club
Cave Creek Golf Course
Chuparosa Golf Course
Club Terravita Golf Course
Club West Golf Club
Continental Golf Course
Coronado Golf Course
CottonFields Golf Club
Cottonwood Country Club
Country Club at DC Ranch, The
Coyote Lakes Golf Club
Coyote Ridge Golf Club
Deer Valley Golf Course
Desert Forest Golf Club
Desert Highlands Golf Club
Desert Mountain Golf Club
Desert Sands Golf Course
Desert Springs Golf Club
Desert Trails Golf Course
Dobson Ranch Golf Course
Dove Valley Ranch Golf Club
Dreamland Villa Golf Course
Eagle's Nest Golf Club
Echo Mesa Golf Course
El Caro Golf Club
Encanto Golf Course
Estancia Club, The
Estrella Mountain Golf Course

Estrella Mountain Ranch Golf Course
Falcon Golf Club
Family Golf Center at Mesa
Fiesta Lakes Golf Course
500 Club Golf Course
Foothills Golf Club
Fountain Hills Golf Club
Fountain of the Sun Country Club
Gainey Ranch Golf Club
Glen Lakes Golf Course
Gold Canyon Golf Resort
Golf Club at Eagle Mountain, The
Grandview Golf Club
Granite Falls Golf Club
Grayhawk Golf Club
Great Eagle Golf Club
Greenfield Lakes Golf Course
Hillcrest Golf Club
Ironwood Country Club
Johnson Ranch Golf Club
Ken McDonald Golf Course
Kierland Golf Club
Kokopelli Golf Resort
Lakes at Ahwatukee Golf Course, The
Lakes East Golf Course (Sun City)
Lakes West Golf Course (Sun City)
Legend at Arrowhead, The
Legend Trail Golf Club
Leisure World Country Club
Links at Queen Creek, The
Longbow Golf Club
Maryvale Golf Course
McCormick Ranch Golf Club
Mesa Country Club
Moon Valley Country Club
Mountain Shadows Golf Club
Oakwood Golf Course
Ocotillo Golf Club
Orange Tree Golf Resort
Painted Mountain Golf Club
Palm Valley Golf Club
Palmbrook Country Club
Palo Verde Country Club
Palo Verde Golf Course
Papago Golf Course
Paradise Valley Country Club
Paradise Valley Park Golf Course
Pebblebrook Golf Course
Pepperwood Golf Course
Phantom Horse Golf Club on South Mountain
Phoenician Golf Club, The
Phoenix Country Club
Phoenix Golf School
Pinnacle Peak Country Club
Pointe Golf Club on Lookout Mountain, The
Pueblo El Mirage Country Club
Quail Run Golf Course
Queen Valley Golf Course
Rancho Manana Golf Club
Raven Golf Club at South Mountain
Red Mountain Ranch Country Club
Rio Verde Country Club
Riverview Golf Course - Mesa
Riverview Golf Course - Sun City
Roadhaven Resort
Rolling Hills Golf Course
Royal Palms Golf Course
San Marcos Golf and Country Club
Scottsdale Country Club
Scottsdale Golf Center
Scottsdale Shadows Golf Course
Shalimar Country Club
Springfield Golf Resort
Stardust Golf Course
Stonecreek, The Golf Club
Sun City Country Club
Sun City North Golf Course
Sun City South Golf Course
Sun Lakes Country Club
Sun Village Resort and Golf Club
Sunbird Golf Resort
Sunland Springs Village Golf Course
Sunland Village East Golf Course
Sunland Village Golf Club
SunRidge Canyon Golf Club
Superstition Springs Golf Club
Tatum Ranch Golf Club
Tempe Family Golf Center
Thunderbird Golf Resort
Toka Sticks Golf Course
Tonto Verde Golf Club
Tournament Players Club of Scottsdale
Traditions Golf Course
Trail Ridge Golf Course
Troon North Golf Course
Troon Golf and Country Club
Union Hills Country Club
Viewpoint Golf Resort
Villa de Paz Golf Course
Villa Monterey Golf Course
Westbrook Village Golf Club
Western Skies Golf Club
Wigwam Resort, The
Wildfire Golf Club

Willowcreek Golf Course and Willowbrook GolfClub

Cemeteries

City of Mesa Cemetery
East Resthaven Park Cemetery
Green Acres Mortuary
Greenwood Memory Lawn Cemetery and Mortuary
Holy Cross Cemetery
Mountain View Memorial Gardens
Paradise Memorial Gardens
Phoenix Memorial Park
St. Francis Cemetery
Sunland Memorial Park
Sunwest Cemetery
Tempe Double Butte Cemetery
West Resthaven Park Cemetery

Common Areas of Housing Developments

Anderson Springs
Arrowhead Homeowners Association - Sierra Verde
Arrowhead Lakes Homeowners Association
Dobson Ranch Homeowners Association - Lakes
Dobson Ranch Homeowners Association - Turf
Estrella Community Association
Foothills Community Association
Garden Lakes
Gila Springs
Islands, The
Kingswood Parke
Lago Estancia
Lake Biltmore Village
Lakes Community Association, The
Lakewood
Leisure World Homeowners Association
McCormick Ranch Property Owners Association
Oakwood Hills
Ocotillo Community Association
Park Shadows Apartments
Pecos Ranch
Scottsdale Ranch Community Association
Springs, The
Sun Harbor Community Association
Sun Lakes Homeowners Association No. 1 - Phase I Common Areas
Sun Lakes Homeowners Association No. 2 - Phase II Common Areas
Sun Lakes Marketing - Phase III Common Areas
Superstition Springs Homeowners Association
Val Vista Lakes
Ventana Lakes

Miscellaneous

Arizona State University Research Park
Glen Harbor Business Park
Honeywell
Perryville State Prison
Sky Harbor International Airport
Tempe Town Lake
Turf Paradise
The Wigwam Resort

APPENDIX 6C
DAIRY OPERATION BEST MANAGEMENT PRACTICES PROGRAM
STANDARD BEST MANAGEMENT PRACTICES

WATER USE CATEGORY 1. DELIVERY OF DRINKING WATER FOR DAIRY ANIMALS **Description:** The level of milk production, season of year, and type of dairy animal housing has a significant effect on the water intake of a dairy animal. The drinking water needs of a lactating cow will vary from 25 to 45 gallons per day. As milk production per cow per day increases, drinking water intake will also increase. Conservation of dairy animal drinking water could best be accomplished by preventing and promptly repairing leaks in the drinking water system.	
BMP 1.1	Install and maintain valves and floats throughout the drinking water system to allow for the isolation of leaks in lines and tanks. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all valves and floats. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the location of the valves or floats.
BMP 1.2	Inspect the drinking water system for leaks daily to ensure that leaks are promptly identified and repaired to prevent water loss. If a leak occurs, stop water flow by isolating the area of the leak and/or repair the leak within 72 hours.
WATER USE CATEGORY 2. UDDER WASHING AND MILKING PARLOR CLEANING **Description:** Udder washing and milking parlor cleaning is the single largest water use at a dairy operation. Floor and wall wash and sanitation of the milking area is necessary for producing a safe product. These systems can be either manual or semi-automatic. The amount of water used also depends on weather conditions not under the control of dairy management. Udder washing and milking parlor cleaning offer the greatest conservation potential at a dairy through management of the system.	
2.1 <u>UDDER WASH SYSTEM</u>	
BMP 2.1.1	Install and operate the udder washing system with automatic timers. When udder washing, use a maximum of one minute of water for the soak cycle followed by a minimum of two minutes off and a maximum of three minutes of water for the wash cycle followed by one minute off. Repeat with a second wash cycle if needed.
BMP 2.1.2	Install a grid no larger than six feet by five feet between sprinkler heads on wash pens installed or renovated after January 1, 2002. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all sprinkler heads and the dimensions of the wash pens. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the location of the sprinkler heads or to the dimensions of the wash pens.

BMP 2.1.3	Install lockout devices so that the wash system can be used only once per group of cows, unless exceptional conditions require an override of the lockout device. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all lockout devices. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the location of the lockout devices.
BMP 2.1.4	Establish and implement an inspection schedule to properly maintain and replace spray heads and timing devices. Inspect all spray heads and timing devices daily to ensure that they are operating correctly. If a device is found to be malfunctioning, repair or replace the device within 72 hours.
2.2 <u>MILKING PARLOR FLOOR AND WALL WASHING</u>	
BMP 2.2.1	Equip all parlor hoses with shutoff valves. Inspect all hoses and valves daily. If a leak occurs, stop water flow by isolating the area of the leak and/or repair the leak within 72 hours.
BMP 2.2.2	If a semi-automatic floor flush system is used, it must be equipped with a timing device to limit the duration of cleaning and be designed to use no more water than necessary unless the water used is water recycled within the dairy operation. The Annual Report required by A.R.S. § 45-632 shall include a description of the flush system that includes the flush schedule and the amount of water used for each flush. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the timing device.
WATER USE CATEGORY 3. CORRAL DESIGN AND MAINTENANCE **Description:** Proper corral design and maintenance will reduce water use in the cow wash pen prior to milking by reducing the amount of wash time necessary to clean the cows. Sloping and maintaining the corral in a dry condition keeps the cows in a cleaner condition.	
BMP 3.1	Slope corrals to prevent standing water and to promote drainage to the waste water system. The Annual Report required by A.R.S. § 45-632 shall include a dairy facility map that shows the corral design and the direction of slope. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to corral design.
BMP 3.2	Scrape, harrow, or drag corrals to eliminate holes and maintain corrals in a dry condition. The Annual Report required by A.R.S. § 45-632 shall include a description of corral maintenance for wet and dry conditions and a maintenance schedule. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in corral maintenance.

WATER USE CATEGORY 4. CLEANING AND SANITIZING MILKING EQUIPMENT

Description: Cleaning and sanitizing milking equipment is necessary to provide a safe dairy product. Water is also used in pre-coolers and vacuum pumps during the milking operation. Water used for this purpose is usually between 5 and 10 percent of the total water use at the dairy operation. This water can be recycled for other uses at the dairy.

4.1 <u>MILK COOLING AND VACUUM PUMP</u>

BMP 4.1.1 If the milk cooling and vacuum pump system is water-cooled and is not a closed system, reuse water from the system to wash cow udders or pens, or for any other uses, consistent with state and federal sanitary codes.

The Annual Report required by A.R.S. § 45-632 shall include a description and diagram of water reuse from the milk cooling and vacuum pump system. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in how water is reused from the milk cooling and vacuum pump system.

4.2 <u>MILK LINE WASHING</u>

BMP 4.2.1 Install and operate the milk line washing system with an automatic or semi-automatic timing device.

The Annual Report required by A.R.S. § 45-632 shall include a description of how the milk line washing system operates. The description shall include the number of cycles per washing and the amount of water used per washing. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the number of cycles per washing and the amount of water used per washing.

4.3 <u>BACK-FLUSH SYSTEMS</u>

BMP 4.3.1 Maintain and service all back-flush systems in accordance with the manufacturer's design specifications and maintenance schedule.

The Annual Report required by A.R.S. § 45-632 shall include the manufacturer's design specifications and a maintenance schedule. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the back-flush system.

APPENDIX 6C
DAIRY OPERATION BEST MANAGEMENT PRACTICES PROGRAM
STANDARD BEST MANAGEMENT PRACTICES

WATER USE CATEGORY 5. DUST CONTROL, CALF HOUSING CLEANING, AND FEED APRON FLUSHING

Description: Control of dust, wastes, and feed residues are necessary for fly control, sanitation, and animal health. This requires water for cleaning and flushing feed aprons and calf housing and for wetting roadways. Conservation potential in this category includes recycling and reusing water, avoiding waste, and employing simple technologies that can reduce the amount of water needed for dust control.

BMP 5.1	If the dairy flushes the cow feed apron, design the systems to recycle water from the cow udder wash system or to pump wastewater and recycle it from the lagoon or wetland area. The Annual Report required by A.R.S. § 45-632 shall include a description of how water is recycled at the operation, an estimate of the amount of water recycled, and the method of estimation. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to how water is recycled.
BMP 5.2	If the calf housing utilizes a flush system to remove animal wastes, design and manage the system so that it uses only the minimum amount necessary and equip with a timer to minimize the duration of each flush. The Annual Report required by A.R.S. § 45-632 shall include a description of how the system is designed and managed to minimize water use, the length of time of each flush, the number of times per day on average that the system is in operation, and a water system map of the facility showing the location of the timer. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the design or operation of the flush system.
BMP 5.3	If dust control practices are used at the facility, the following dust control methods should be used: paving, aggregate, chemical binding agents, or dairy wastewater if consistent with state and federal standards. If potable water is used for dust control it must be used as efficiently as possible. The Annual Report required by A.R.S. § 45-632 shall include a description of the dust control technology(ies) used, the area on which dust control is practiced, and the amount of water used for dust control. If water use is estimated, provide a description of how water use is estimated. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to dust control practices.

APPENDIX 6C
DAIRY OPERATION BEST MANAGEMENT PRACTICES PROGRAM
STANDARD BEST MANAGEMENT PRACTICES

WATER USE CATEGORY 6. DAIRY ANIMAL COOLING

Description: Dairy animal cooling is an effective method to improve milk production per cow and reproductive efficiency, which are important factors in dairy profitability. Animal cooling is also an important factor in improving animal health. The amount of water required depends on the type of method or methods used to cool cows, the maintenance practices for the system, and the hours of usage. Methods to conserve water for each cooling system are available to dairy farm management.

6.1 HOLDING PEN COOLING

BMP 6.1.1	Design and operate independent fan and spray systems to ensure that water is used efficiently under all weather conditions. The Annual Report required by A.R.S. § 45-632 shall include a diagram demonstrating that fans and spray systems are used independently and provide information on how the system is managed depending on weather conditions. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the fan and spray systems.

6.2 COW EXIT AND RETURN LANES COOLING

BMP 6.2.1	Use leaf gate, wand switch, electric eye, or motion (proximity) indicators to automatically activate the water valve. The Annual Report required by A.R.S. § 45-632 shall include a description of the activation device used at the dairy operation including the length of time the water valve is in operation and the amount of water used; include the average number of times per day that the device is activated in a year. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in activation device.

6.3 FEED LINE COOLING

BMP 6.3.1	Locate the feed line cooling system to take advantage of prevailing winds in order to place water directly on the dairy animal. Equip the system with timers to control the duration of use. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all timers and the direction of prevailing winds. Report the length of time the timer is in operation, and the average number of times per day that the system is in operation in a year. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the feed line cooling system or timers.

6.4 CORRAL SHADE COOLERS	
BMP 6.4.1	Equip corral shade coolers with thermostats or timers to control operation time. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all thermostats or timers and report the average daily length of time the coolers are in operation in a year. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the thermostats or timers.
BMP 6.4.2	Establish an inspection schedule to ensure regular maintenance of nozzles and water filter systems. The Annual Report required by A.R.S. § 45-632 shall include an inspection and maintenance schedule. This schedule shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the maintenance schedule.
WATER USE CATEGORY 7. DAIRY ANIMAL FEED PREPARATION **Description:** Water is used in the preparation of dairy animal feed at dairy operations to pre-soak cereal grain for processing (rolling and flaking). A large use of water in feed preparation is its addition to the total mixed ration (TMR) to improve feed intake. The amount of water needed depends on the dryness of the feed in the ration. The total amount of water added to the feed could equal 20 percent of the ration. The greatest conservation potential for feed preparation rests with leak detection and prevention.	
BMP 7.1	Install shutoff valves at each water source used for feed preparation to allow for the isolation of leaks. If a leak occurs, isolate the area of the leak and/or repair the leak within 72 hours. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the facility showing the location of all valves. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the location of the valves.